MANUAL OF INDIAN FOREST UTILIZATION

By

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MANUAL OF INDIAN SILVICULTURE

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PREFACE

This Manual is intended primarily as a textbook for Indian Forest Ranger students, and does not aim at being a comprehensive or complete manual of Indian forest utilization.

Troup's *Indian Forest Utilization* was first published in 1907, and the second edition was issued in 1912. Since that date, no other general textbook on Indian forest utilization has been published. Troup's manual is now out of print and is also somewhat out of date. The publication of a fresh textbook, therefore, requires no apology, and as there is now no Provincial Forest Service course in India, it was felt that an elementary treatment of the subject would serve a more useful purpose than a more complete and comprehensive work on utilization in all its aspects.

The compilation of a manual is seldom possible without the co-operation of several workers, and acknowledgements are due to all those who have helped to bring this work to completion.

In the first place, it may be stated that reference has been made freely to Troup's *Indian Forest Utilization*, and that invaluable work has been made the basis of this Manual. The arrangement of Troup's manual has been altered somewhat in order to bring this new work up-to-date, but full acknowledgements are due to the late Professor Troup for the valuable information culled from his book. Schlich's *Manual of Forestry* (Vol. V, Forest Utilization) has also been referred to frequently, and the inspiration and help derived from this invaluable work is most gratefully acknowledged.

Special acknowledgements are also due to those officers who have written up parts of the Manual. To Mr A. P. F. Hamilton, I.F.S., for the portion on Felling, Conversion and Transport of Wood, to Dr K. A. Chowdhury for his section on Wood Technology, to Mr L. N. Seaman (Timber Testing), to Dr S. N. Kapur (Seasoning), to Mr S. Kamesam (Wood Preservation), to Mr W. Nagle (Sawmills and Woodworking), and to the late Mr F. D. Ardagh, I.F.S., for his valuable help on Minor Forest Products.

I have also to thank Mr R. N. Parker, I.F.S., Mr H. G. Champion, I.F.S., and Mr L. N. Seaman, late Officer-in-Charge, Timber Testing, for their help in checking the original typescript; and Mr D. Stewart, I.F.S., Mr S. Ramaswami, I.F.S. Diploma, and Messrs K. N. Tandon and K. K. Sarkar, for helping to correct the proofs and arrange the Index. Acknowledgements are also due to the Oxford University Press for their helpful suggestions during the printing of the Manual.

Unfortunately, nearly 8 years have elapsed since the Manual was first written, and some of the information recorded is not quite so up-to-date as it might be. Information on Forestry subjects has accumulated with great rapidity during the last few years, and Utilization has, perhaps, made greater advances than any other branch of Forestry. When Troup revised his manual in 1912, such subjects as Kiln Seasoning, Timber Testing, Wood Technology, and Wood Preservation were almost unknown in India, whereas, in the present day, they are amongst the most important branches of modern timber utilization. All these subjects have been explained in elementary language in the present work, and a great deal of information and data of value has been recorded. It is possible, therefore, that this Manual, while being of educational help to Forest Ranger students, will also prove of interest to other Forest Officers in India, since it contains a lot of information which has not been formerly recorded.

H. TROTTER

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Part I

UTILIZATION OF WOOD

I

ANATOMICAL STRUCTURE AND PROPERTIES OF WOOD

CLASSIFICATION OF THE VEGETABLE KINGDOM. THE CELL; cell division—cell enlargement and cell-wall thickening—cell hardening or lignification. THE GROSS STRUCTURE; pith—heartwood and sapwood—bark—spring wood and summer wood: early wood and late wood—growth rings (annual rings)—grain and texture. THE MINUTE STRUCTURE; pores or vessels and tracheids—ring-porous and diffuse-porous—Tyloses and their importance in the utilization of wood—fibres—parenchyma cells or soft tissues—pith flecks—wood rays or medullary rays—ripple marks— resin canals—comparison between the gross structure of gymnosperms and angiosperms. THE GROSS PHYSICAL FEATURES; colour—lustre—odour—weight. THE MECHANICAL PROPERTIES; strength (timber testing)—bending tests—compression tests—shear—fissility—hardness—other mechanical properties. OTHER PROPERTIES; seasoning properties—durability—classification of woods in order of durability—aptitude for being worked—combustibility and heating power—calorific value of wood. DEFECTS IN WOOD; defects due to abnormal growth—defects due to rupture of tissues—defects resulting from wounds.

CLASSIFICATION OF THE VEGETABLE KINGDOM

The vegetable kingdom includes all types of vegetation from the simplest to the most complex. The whole kingdom may be divided into two groups: spore-plants and seed-plants. These again may be subdivided into smaller groups as shown below :—

- Spore-plants
  - Lower
    - Fungi
    - Bacteria
    - Algæ
  - Higher
    - Mosses and liverworts
    - Ferns, horse-tails and club-mosses
- Seed-plants
  - Gymnosperms
    - Cycads
    - Gingko: maidenhair tree
    - Conifers: pines, spruces, etc.
  - Angiosperms
    - Dicotyledons: teak, sal, etc.
    - Monocotyledons: palms, bamboos, etc.

Of these, forest officers are mainly concerned with the dicotyledons (broad-leaved trees) and the conifers (needle-leaved trees), which comprise the main portion of forest products. Since shrubs, herbaceous plants and lianas are too small to come directly under the heading of *timber* utilization, only plants of tree-size will be considered at this juncture.

The Cell

The basis of all life, whether plant or animal, is the living substance called protoplasm or cell-body. In the majority of plants, protoplasm does not occur in a naked state, but is enclosed in a thin layer called the cell-wall. If a thin longitudinal section is cut from the apex of one of the higher plants and is examined under a microscope, it will show a number of well-packed cells of more or less rectangular shape. Each cell contains a spherical body in the centre, called the nucleus, which directs and controls the vital activities of the cell. The space between the nucleus and the cell-wall is filled up with a fine granular substance called cytoplasm. A young plant cell, therefore, consists of protoplasm (i.e. cytoplasm and a nucleus) and a cell-wall.

Having obtained an elementary idea of what a cell is, the different stages in the life history of a cell must now be considered. There are three main stages in the development of a cell, namely (1) cell division, (2) cell enlargement and cell-wall thickening, and (3) cell hardening or lignification.

(1) *Cell division*

Growth takes place at the growing points of a plant body by means of cell division. The most common method of division may be briefly described as follows: First the nucleus, after passing through many complex processes, divides itself into two equal parts. Then a very thin cell-wall is formed, partitioning the former mother-cell into two equal parts, called daughter-cells. Thus eventually each new cell has its own nucleus, cytoplasm, and cell-wall, forming a complete unity.

(2) *Cell enlargement and cell-wall thickening*

The next stage in the life history of a cell is cell enlargement. The cell of a woody plant usually increases in course of time to many times its original size. Its final size and shape depend on the pressure exerted by surrounding cells, and also on the physiological function it has to perform during the life of the plant. Cell enlargement and cell-wall thickening may take place simultaneously. A newly-formed cell starts with only a primary wall, but as it matures, a secondary wall is deposited on the first from the inside. During the course of secondary thickening, certain places in the primary cell-wall are left

uncovered. These thin places in the wall are the means of communication between two adjacent cells and are known as 'pits'. Again, some cells show tertiary thickening, the formation of which is the same as for secondary thickening.

(3) *Cell hardening or lignification*

The last stage in the life history of a cell is cell hardening or lignification. This is a chemical process, the details of which need not be discussed here, but it may be said that after the cells have turned woody by lignification, no further cell enlargement can take place. The process of lignification is not, however, common to all types of cells. Speaking broadly, those cells which are to give support and rigidity to the tree are usually lignified, whereas others may or may not be.

The Gross Structure

Having obtained a general idea of the original unit of wood, namely the cell, it is possible to pass on to a consideration of wood tissues and wood structures, and as wood is composed of untold millions of cells of many different shapes, sizes, and functions, the subject is not a simple one.

In the first place, a piece of wood can be examined with the naked eye, with a low-power lens, or a high-power microscope, each method revealing various features in accordance with the degree of enlargement. Secondly, the examination can be made on three different surfaces, or, in other words, on a cross, radial, or tangential section. It is the intention here to deal only with the grosser structures of wood, namely those seen with the naked eye or with an ordinary pocket lens. The microscopic features of wood are a separate study in themselves and are beyond the scope of this Manual.

Taking the larger features first, the following can be seen in most woods without the aid of any magnifying instrument:—

Pith

The soft portion in the centre of a plant is called the pith. Its size and shape vary in different species. For example, a teak twig has rather a large and rectangular pith, while the pith of a chir pine twig is comparatively small, and varies from being star-shaped to nearly circular. Usually twigs and young stems have a proportionately larger pith than that found in mature trees.

Heartwood and sapwood

As a rule, the darker-coloured central portion found in most trees is called heartwood, while the lighter-coloured outer portion is known as sapwood. Colour distinction is not, however, always a true criterion. In Himalayan silver fir and

spruce, for example, there is no colour distinction between the sapwood and heartwood, although, physiologically, heartwood is always present in the mature wood of any species.

In the same way, colour may also be misleading in suggesting that all dark-coloured wood in the centre of a tree is heartwood. This is not always so, as can be seen in the case of the ebonies, in which the black parts of the wood bear no relation to the true heartwood.

In sal also, colour is not always an indication of true heartwood, and in this species sapwood of a reddish colour like heartwood is not infrequently found. Such wood appears to be in a transition stage and is known as *kutcha-pukka* heartwood.

Physiologically, heartwood is dead and does not take any active part in the life of the tree except to give it rigidity. All heartwood cells are dead cells or, in other words, skeleton cells consisting of cell-walls. Sapwood on the other hand is composed mostly of living cells and, as its name implies, is for the conduction of sap (liquids). Experience has shown that under ordinary conditions heartwood is almost always more durable than sapwood. From an anatomical point of view, however, there is no difference between sapwood and heartwood, but in some cases heartwood contains chemical deposits like gums and resins which may serve as natural preservatives of the wood, while in the sapwood these substances are not present in the same form.

Bark

The term 'bark' in its widest sense includes all tissues, dead and living, outside the cambium, which is a thin active layer of growing cells in between the bark and the wood. The outer dead bark often shows fissures and cracks. In fact, different timber trees show different types of fissures or cracks on their barks, and this characteristic is of some diagnostic value in the identification of logs. For instance, the bark of teak has numerous shallow fissures, while that of sal shows deep longitudinal furrows.

Spring wood and summer wood: early wood and late wood

The terms 'spring wood' and 'summer wood' originated in the countries of temperate regions, where there are two distinct growth seasons, namely spring and summer. In India, these terms cannot be applied in the same sense, for growth activities of trees do not always correspond to the ordinary spring and summer seasons. On the other hand, some trees in India do show a variable intensity of growth, a rapid growth in the form of thin-walled cells followed by a slow growth of thick-walled cells. The former may be called 'early wood' and the latter 'late wood'.

Growth rings (annual rings)

The greater the difference between late wood and early wood, the more prominent is the 'growth ring', often also called 'the annual ring'.[1] The rate of growth depends on many factors such as species, locality, rainfall, atmospheric conditions, and the condition of the soil in which the tree grows. Many Indian trees do not show any distinct annual or seasonal growth ring, due to the fact that their intensity of growth is more or less the same throughout the growth season, and one year's growth merges into the next year's growth without any perceptible change. The rapidity of growth is usually described in terms of rings per inch. Fast growth is indicated by 1 to 4 rings per inch. The average for Indian trees usually lies between 5 and 12 rings per inch, while 20 rings to the inch may be considered as slow growth.

Grain and texture

These two terms have often been loosely applied and this has caused much confusion. For the sake of clearness, it seems advisable, therefore, to define them here. 'Grain' applies to the alignment of the cells, i.e. the arrangement of the cells with regard to the axis of a tree, and thus the grain of a timber is described as straight, cross, spiral, interlocked, curly, or wavy. The term 'texture' applies to the size of the cells in the wood and their proportion in unit volume, and 'fine' and 'coarse' are the two terms normally used as modifying adjectives for texture. Among the common Indian timbers, box (*Buxus sempervirens*), sandal wood (*Santalum album*), and haldu (*Adina cordifolia*) are fine-textured woods, while sal (*Shorea robusta*), kokko (*Albizzia lebbek*), and teak (*Tectona grandis*) are coarse-textured.

THE MINUTE STRUCTURE

Passing to the smaller elements of wood structure, the following features can be seen, sometimes with the unaided eye, but in all cases more clearly with a pocket lens :—

Pores or vessels and tracheids

Wood is composed of minute tube-like cells. Their size and shape are determined mainly by the physiological and mechanical functions they have to perform in the life of the tree. In conifers, tracheids are the main longitudinal elements, and their function is to conduct liquids (sap) and also to give rigidity

[1] As a ring shows difference in growth from season to season, which may not be one full year, it seems judicious to use the term 'growth ring' instead of 'annual ring', which is the term used in older textbooks.

to the tree. These tracheids are minute, narrow, thick-walled cells with closed tapering ends. In broad-leaved trees there is a division of labour; there are vessels for conduction, and fibres for strength. The vessels or pores are comparatively short cells with a wide opening, and they are usually visible to the eye or with a hand lens. The wood of broad-leaved species is, therefore, called 'porous' and that of conifers 'non-porous'.

Ring-porous and diffuse-porous

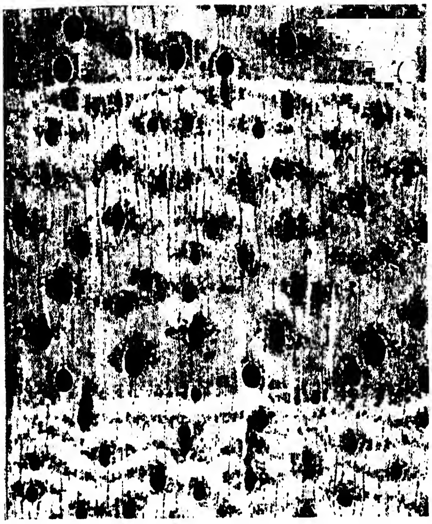
Porous timbers are divided into two groups, namely, ring-porous and diffuse-porous. In ring-porous woods the pores formed during the early part of the growing season are comparatively larger than the pores formed during the latter part of the growing season, and they form a distinct band along the early part of the ring. This can be clearly seen in such woods as teak (*Tectona grandis*) and toon (*Cedrela toona*). In diffuse-porous woods, the early and the late pores show no appreciable difference in their size, and they are more or less evenly distributed throughout the ring. This type of pore distribution can be seen in sal (*Shorea robusta*) and haldu (*Adina cordifolia*). Again, pores of some species show a tendency towards various radial arrangements, and this character is taken into consideration in the classification and identification of timbers. Examples of woods with this pore formation are *Diospyros* spp. and *Holarrhena antidysenterica*.

Tyloses and their importance in the utilization of wood

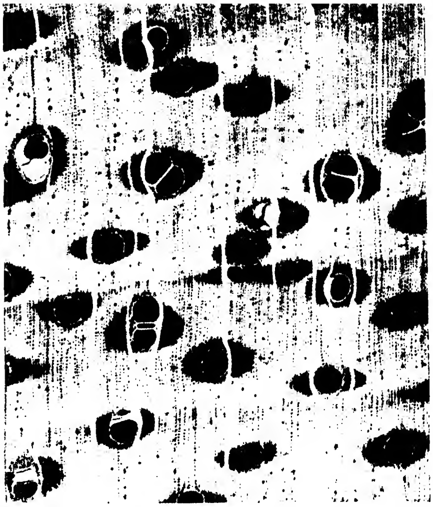
Tyloses are in-growths found in the pores of certain species. They are formed by the enlargement of a pit membrane, and may remain thin-walled or become lignified. With a hand lens they appear as foam-like structures, often filling the entire pore-cavity. The greater durability of heartwood has often been attributed to tyloses, which control, at least to some extent, the moisture and temperature of the wood, and thus help to protect it against fungal attack. When present, therefore, they are often an indication of durability. But the presence of tyloses is not without its drawbacks, as impregnation with creosote or other preservatives is rendered more difficult in the heartwood of tylosed species, since tyloses tend to close up the pores and prevent the passage of liquids through the wood.

Fibres

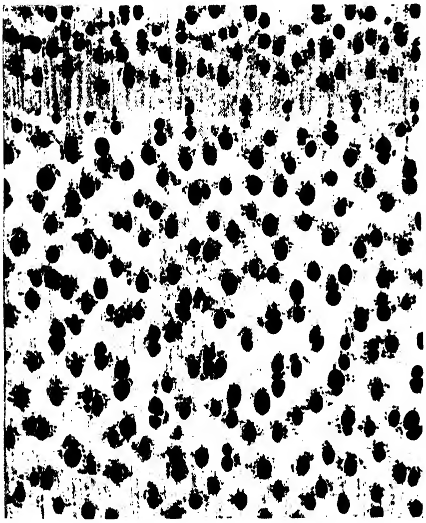
Structurally, fibres are like the tracheids of conifers. They are present only in broad-leaved species and are responsible for the strength of wood. Individually they are too minute to be visible except with a microscope, but collectively they show different arrangements and distribution which are of importance in hand-lens identification of timbers.



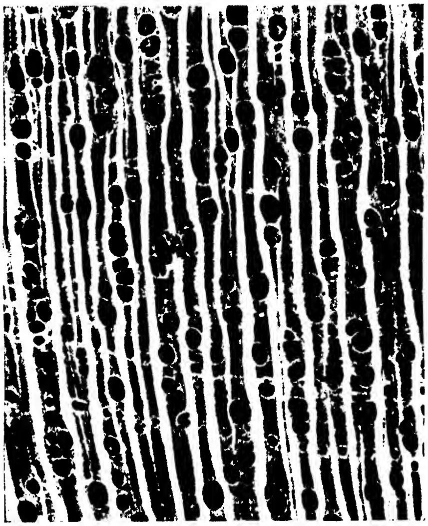
1. Laurel (*Terminalia tomentosa*)



2. Kokko (*Albizzia lebbek*)



3. Yon (*Anogeissus acuminata*)



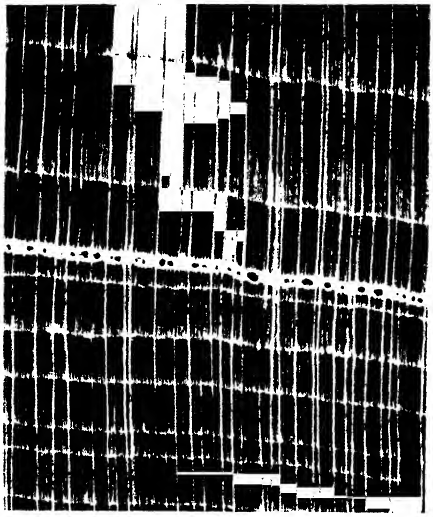
4. Sal (*Shorea robusta*)

PLATE I. Photomicrographs showing the distribution of parenchyma in laurel, kokko, yon, and sal

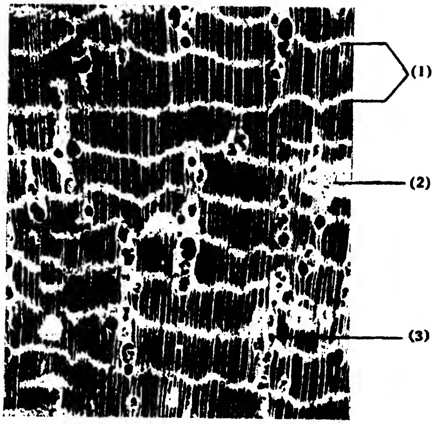
1. Terminal or initial, delimiting seasonal growth
2. Forming eyelets round the pores
3. Arranged in thin bands round the pores
4. Diffuse, distributed irregularly throughout the wood

Magnification, 15 times — *Photomicrographs by K. A. Chowdhury*

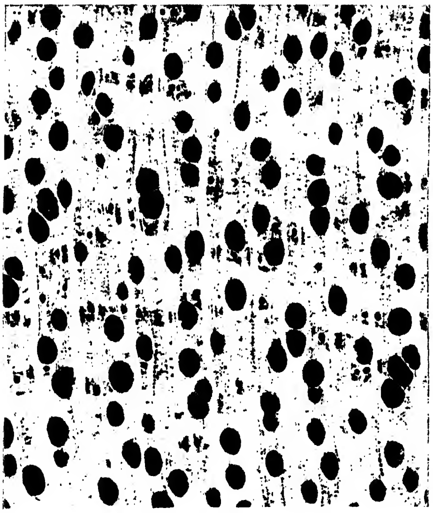
Facing p. 8.



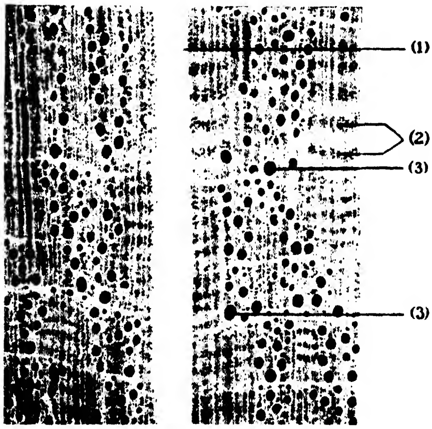
1. Deodar (*Cedrus deodara*)



2. Mesua (*Mesua ferrea*)



3. Gurjun (*Dipterocarpus alatus*)



4. Ban oak (*Quercus incana*)

PLATE II. Photomicrographs of deodar, mesua, gurjun, and ban oak

1. Non-porous wood with a long concentric band of resin canals
2. Prominent tangential bands of parenchyma (1), pith fleck (2), and pores with a tendency towards radial grouping (3)
3. Scattered groups of resin canals, surrounded by parenchyma cells
4. Conspicuous wood rays (1), tangential bands of parenchyma (2), and tyloses (3)

Magnification, 15 times *Photomicrographs by K. A. Chowdhury*

Facing p. 9.

Parenchyma cells or soft tissues

Parenchyma cells or soft tissues are minute, short, thin-walled cells. Their function is storage and conduction of food materials. Like fibres they are not individually distinguishable to the eye, but collectively their arrangement and distribution are of importance in the classification and identification of timbers.

A few of the more important types or patterns of parenchyma arrangement are as follows:—

Parenchyma is called 'terminal' or 'initial' when a season's growth is delimited by the formation of a row of parenchyma cells. Laurel (*Terminalia tomentosa*) shows this type of distribution. In other species like kokko (*Albizzia lebbek*) the parenchyma cells form a halo or eyelet round the pores. Yon (*Anogeissus acuminata*) shows another type of arrangement, in which the parenchyma cells are in a thin band round the pores. The fourth type is called 'diffuse'. In this type the distribution is more or less irregular throughout the wood, e.g. sal (*Shorea robusta*) (see Plate I).

It may be noted here that parenchyma arrangements are not definitely limited to the four types mentioned above, nor does each distinct type occur in different species. In practice all kinds of gradations and combinations are observed.

Pith flecks

Certain timbers show irregular patches of parenchyma cells in the midst of fibrous elements. These patches are called 'pith flecks' and they develop as a result of attack by insects in the cambium. On a board face they sometimes show rather conspicuously against the natural colour of the wood and may be mistaken for resin canals. Unless they are of very large size they are not serious defects in any timber. The presence of pith flecks in certain timbers is, however, of some diagnostic value, for some species are more liable to form pith flecks than others (see Plate II).

Wood rays or medullary rays

Wood rays, or medullary rays as they are often called, are groups of horizontally arranged cells, running radially from the bark towards the centre of the tree. Their function is storage and radial conduction of food materials. On the end surface of a piece of wood, they appear as radial straight lines, sometimes not visible to the unaided eye. On the tangential surface also, they are not always visible to the eye, but with a hand-lens or by moistening the surface with water, one can easily see their somewhat dark, spindle-shaped structure. On the radial surface, they are also not always conspicuous, except in the case of unusual height, when they appear as small plates and produce the effect known as 'silver

grain'. This phenomenon is common in *Quercus* species (see Plate III) and it is a common practice amongst timber users to cut certain species 'on the quarter', i.e. along the direction of the wood rays, in order to obtain the silver grain figuring.

Rays may be differentiated into two types, namely primary rays and secondary rays. The former radiate from the organic centre of the stem, while the latter are interpolated amongst these original rays at later stages. Rays may also be uniseriate (one cell wide) or multiseriate (several cells wide), and are usually described as fine, medium or coarse.

Ripple marks

In certain timbers, the wood rays are so arranged as to bring about, on the tangential surface of the wood, the effect of fine, equidistant, wavy lines at right angles to the direction of the grain. These are called ripple marks. Andaman padauk (*Pterocarpus dalbergioides*) is a typical example of a wood with this phenomenon. Ripple marks are not often visible to the naked eye, but they can be clearly seen with a pocket lens.

Resin canals

Certain timbers of both conifers and broad-leaved trees have resin cavities in the wood which are usually known as resin canals. The dark streaks that one often finds on boards of spruce and pine are due to the presence of resin canals.

The arrangements of resin canals are usually of two types. In sal (*Shorea robusta*), toon (*Cedrela toona*) and deodar (*Cedrus deodara*), for example, they are found in bands of variable length at irregular intervals, while in pines (*Pinus* spp.), spruces (*Picea* spp.) and *Dipterocarpus* species, they are more or less evenly distributed throughout the wood (see Plate III).

The colour of the resin deposits in certain woods has some diagnostic value. For example, timbers of the *Dipterocarpaceae* usually have resins of a whitish colour, which is seldom found in timbers of any other family.

Comparison between the gross structure of gymnosperms and angiosperms (monocotyledons and dicotyledons)

As has been mentioned before, gymnosperms have non-porous wood while angiosperms have porous wood. On superficial examination, resin canals of some coniferous woods look like pores, but careful examination will reveal that they are not true pores.

Although the woods of monocotyledons and dicotyledons are fundamentally the same, yet in minute detail they show differences. As a rule, there is no secondary thickening in the monocotyledons, and the plant-body mainly consists

of primary tissues—secondary thickening taking place only in rare cases. There is also a difference in the distribution of the vascular bundles. In monocotyledons, the vascular bundles are usually scattered throughout the stem, the largest lying near the centre and smallest crowding towards the periphery. In dicotyledons, the vascular bundles are arranged in a ring, or there is a vascular cylinder enclosing the pith.

The Gross Physical Features

Colour

Colour in wood is a very variable feature, yet it has some diagnostic value, especially when timbers are very similar in structure but show a marked and constant difference in colour. For instance, Andaman padauk (*Pterocarpus dalbergioides*) and Burma padauk (*Pterocarpus macrocarpus*), in spite of their similar structure, can often be separated by their colour.

As a rule, wood darkens on exposure. This is due to a chemical action which takes place under ordinary light and atmospheric conditions. The rate at which a timber changes its colour depends on the nature of the chemicals present in it. In the case of *Michelia excelsa* for example, the chemical change on a freshly cut surface is so fast that one can sometimes see the colour turning, within a few minutes, from yellowish green to brownish grey. Teak is another timber which sometimes changes colour very rapidly. Describing wood by its colour is, therefore, a procedure which is fraught with danger, and in these days of modern tinting methods for finishing wood to suit the circumstances, colour can be most misleading.

Lustre

Some timbers have a characteristic way of reflecting light from the cell-walls. This feature is known as lustre. Lustre can usually be seen on the longitudinal surface, and more often on the longitudinal-radial surface. Among conifers, spruce has a characteristic pearly lustre. Quarter-sawn timber of broad-leaved trees, which have comparatively high wood rays, often reflects light from its rays and thereby gives a beautiful figure to the wood. This phenomenon has already been mentioned under the subject of wood rays as being the cause of silver grain. Good examples of this ray lustre can be seen in *Quercus* and *Carallia* species, while *Albizzia lebbek* has a very characteristic lustrous sheen which is enhanced by a high polish.

Odour

Odour is another feature which can be very misleading but which is sometimes used for the identification of woods. For example, deodar (*Cedrus deodara*)

has such a characteristic odour that it can seldom be mistaken for that of any other wood. Due to the abundance of chemical deposits in the heartwood, odour is usually more pronounced in the heartwood than in the sapwood, though sap itself often has a powerful odour. Sometimes odour becomes faint on an exposed surface, but it can be easily recovered by making a fresh cut and moistening the wood with water. *Santalum album* is another example of a distinct odour, while the characteristic smell of teak is well known to most persons in India.

Weight

The weight of wood varies not only in different species but also in the same species, and is dependent on a number of factors. Among these factors, the most important, from a utilization point of view, is the moisture content. 'Moisture content' is a technical term used to indicate the amount of moisture present in wood, and is expressed as a percentage of the oven-dry weight of the wood (see Chapter VIII, 'Seasoning of Timber').

The moisture content of green timber may vary from about 30 to 200 per cent. Green timber, on exposure, first loses the free water in the cell cavities, and then later the water absorbed in the cell-walls. Under ordinary atmospheric conditions, the moisture content can be brought down to from 8 to 15 per cent. Timber dried in this fashion is known as air-dry wood. Again, timber can be dried under artificial conditions, such as in seasoning kilns, to any percentage of moisture content required. Lastly, timber can be dried in an oven till practically all the moisture in the wood has been removed. In giving the weight of any timber, it should, therefore, be stated whether the wood is green, air-dry, kiln-dry, or oven-dry, and if possible the moisture content should be mentioned.

The following classification for describing the weight of woods is based on air-dry (12%–15% moisture) weights and volumes determined at the Forest Research Institute, Dehra Dun :—

	Weight per cu. ft.
Very light	up to 22 lb.
Light	23–27 lb.
Moderately light	28–32 lb.
Moderately heavy	33–39 lb.
Heavy	40–49 lb.
Very heavy	over 49 lb.

The Mechanical Properties

Strength (*timber testing*)

It is customary to apply the word 'strength' to wood in a very loose way, overlooking the fact that on account of the lack of homogeneity of its nature and

its fibrous stru ture, a timber which may be described as strong in one respect may not be equally strong when used for a different purpose. For example, babul (*Acacia arabica*) is 8 per cent stronger than dhaman (*Grewia tiliaefolia*) when used as a beam or rafter, but when employed as a post or strut it is about 13 per cent inferior to the latter, while *eng* (*Dipterocarpus tuberculatus*) as a beam is 7 per cent superior to East Indian satinwood (*Chloroxylon swietenia*), but as a post is 13 per cent inferior.

It is true that the strength of wood varies in a general way, *other things being equal*, with its density, but it must not be forgotten that structure as well as density has a pronounced influence on strength in some particulars, and density may be regarded only as a rough indication of mechanical properties when no better data are available. Strength is also dependent on the condition of seasoning and soundness of the wood, absence of defects, and the presence or absence of internal stresses caused by uneven drying.

It is not proposed here to discuss timber testing methods[1] but only to consider, in a broad way, the application of test results to the selection of woods for various uses. The final choice of the best species for any given purpose must be based on a combination of different qualities, including strength, ability to keep shape, durability, etc. At present we are concerned with strength only.

The results of strength tests are presented in various ways, of which, for the purposes of this chapter, the most important are, (1) average strength values for green material, (2) average strength values for air-dry material, and (3) applied results, known as 'suitability figures', showing the relative suitability of different species for particular uses, based on a combination of various strength test values, and expressed as percentages of the corresponding properties of teak. Tables of test results are available in various departmental publications issued by the Forest Research Institute, Dehra Dun,[2] and will not be repeated here.

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[1] Information concerning timber testing methods employed in India may be found in:—

Project No. 1, Mechanical, Physical, and Structural Properties of wood grown in India, Tests on Small Clear Specimens, Scheme of Operation No. I, by L. N. Seaman.

Project No. 2, Tests of Indian Timbers in Structural Sizes, Scheme of Operation No. I, by L. N. Seaman.

Special Lecture Notes on Timber Strengths and Timber Testing for Indian Forest Students, by L. N. Seaman.

Brief Lectures on the Application of Research to the Utilization of Timber, by L. N. Seaman.

[2] *Indian Forest Records. Interim Report on the work under Projects No. I and No. O by the Section of Timber Testing, including the results of the Mechanical and Physical Tests on certain of the commoner Indian Timbers up to the end of* 1922, by L. N. Seaman.

Indian Forest Records. Second Interim Report on the work under Project No. I by the Section of Timber Testing, including the results of the Mechanical and Physical Tests

For ready reference however a list of Indian timber species arranged in order of 'strength as a beam' is given below.

In order to obtain as complete data as possible on the relative strength characteristics of Indian timbers, numerous laboratory tests have to be carried out in order to obtain information on the several different strength properties of wood. The most important of these tests are those on bending, compression, shear, fissility, hardness and torsion.

Bending tests

Bending tests, sometimes called transverse tests, are conducted with very slowly applied loads—static bending tests, and with loads applied as blows—impact bending tests. The specimens to be tested are usually supported at the ends and loaded at the middle, though sometimes variations in the loading methods are introduced. Data obtained from these tests are used to determine:

(1) Strength as a beam (sometimes called transverse strength).
(2) Toughness and shock-resisting ability.
(3) Flexibility and toughness.
(4) Elasticity.

(1) Strength as a beam.—Strength as a beam indicates the fitness of species for use as girders, rafters, axles, yokes, and other purposes in which they are liable to breakage by bending. There is a considerable variation of strength among different specimens of the same species, and even between different samples taken from the same tree, so that statements regarding the relative strengths of different timbers are based on the average results of a great many tests, and when test data are used as the basis of design, a suitable allowance must be made depending on the probable strength of the weakest piece.

In the following list some Indian timbers are arranged in groups according to their strength as a beam. The different members of each group are arranged in order of their relative strength values.[1] As a general guide to the use of the species for beams, rafters, etc., any of the species contained in any one group can be designed to the same dimensions as the species which is mentioned as

on certain of the commoner Indian Timbers up to the end of 1924, by L. N. Seaman, assisted by C. R. Ranganathan.

The Mechanical and Physical Properties of Himalayan Spruce and Silver Fir, by L. N. Seaman, assisted by C. R. Ranganathan.

Indian Forest Records. Third Interim Report on Project I—Results of work done up to the end of 1932, by Limaye and Seaman.

Indian Forest Records. Interim Report on Project II—Strength Tests of Timbers in Structural Sizes with Test Results up to 1932, by L. N. Seaman.

[1] The lists are arranged in two columns, to be read successively from head to foot.

typical of that group. For example, in the group of 'Very strong' timbers, the other species may be treated as having approximately the same strength as teak. More exact strength calculations and design tables of safe working stresses are available from the Forest Research Institute, Dehra Dun, for the use of engineers, forest officers, and anyone else requiring them.

Exceptionally strong (*pyinkado* class)

Mesua ferrea
Pterocarpus macrocarpus
Schleichera trijuga
Shorea obtusa
Xylia dolabriformis

Extremely strong (sal class)

Hopea parviflora
Anogeissus acuminata
Acacia arabica
Dipterocarpus tuberculatus
Pentacme suavis
Shorea robusta
Grewia tiliaefolia
Heritiera minor
Dipterocarpus turbinatus
Terminalia tomentosa (U.P.)
Pterocarpus marsupium

Very strong (teak class)

Xylia xylocarpa
Hopea odorata
Tectona grandis (Burma and Malabar)
Anogeissus latifolia
Pterocarpus dalbergioides
Terminalia belerica
Dipterocarpus macrocarpus
Acrocarpus fraxinifolius
Lagerstroemia microcarpa
Pentace burmanica

Strong (jaman class)

Dalbergia latifolia
Artocarpus hirsuta
Dalbergia sissoo
Parashorea stellata
Terminalia paniculata
Terminalia bialata
Eugenia jambolana
Dipterocarpus alatus
Calophyllum tomentosum
Lagerstroemia parviflora
Morus alba
Tectona grandis (Central Indian region)
Albizzia lebbek
Albizzia procera
Terminalia tomentosa (Madras)

Moderately strong (haldu class)

Adina cordifolia
Dillenia indica
Cedrus deodara
Phoebe hainesiana
Lagerstroemia flos-reginae
Cedrela serrata

(7) *Chukrasia tabularis*
Hardwickia binata
Mangifera indica
Podocarpus neriifolia
Juglans fallax
Diospyros melanoxylon
Michelia excelsa

Somewhat weak (chir class)

Mitragyna parvifolia
Abies pindrow
Bischofia javanica
Pinus longifolia
Michelia champaca
Holoptelea integrifolia
Shorea assamica

Weak (lampati class)

Picea morinda
Duabanga sonneratioides
Cedrela toona
Lannea grandis
Boswellia serrata
Pinus excelsa

Very weak (semul class)

Hymenodictyon excelsum
Canarium euphyllum
Bombax insigne
Bombax malabaricum
Cryptomeria japonica

(2) Toughness and shock-resisting ability.—Values for toughness and shock-resisting ability are based on the amount of work absorbed by specimens in bending tests, and on the results obtained in impact bending tests. The possession of these qualities is desirable in woods used for hammer and axe handles, motor car and aeroplane parts, and for any purposes where the wood is to be subjected to blows or sudden stresses.

The following species are arranged in order of their shock-resisting ability, the two columns to be read successively from head to foot:—

Anogeissus latifolia
Pterocarpus macrocarpus
Mesua ferrea
Schleichera trijuga
Shorea obtusa
Xylia dolabriformis
Anogeissus acuminata
Grewia tiliaefolia
Dalbergia sissoo
Albizzia procera
Morus alba
Pterocarpus marsupium
Shorea robusta
Terminalia tomentosa (U.P.)
Heritiera minor
Hopea parviflora
Dalbergia latifolia
Pentacme suavis
Lagerstroemia parviflora
Dipterocarpus turbinatus
Terminalia belerica
Terminalia tomentosa (Madras)

Mitragyna diversifolia
Holoptelea integrifolia
Eugenia jambolana
Pentace burmanica
Tectona grandis (Burma and Malabar)
Dipterocarpus macrocarpus
Mangifera indica
Hopea odorata
Pterocarpus dalbergioides
Parashorea stellata
Tectona grandis (Central Indian region)
Dipterocarpus alatus
Chukrasia tabularis
Adina cordifolia
Artocarpus hirsuta
Xylia xylocarpa
Lagerstroemia flos-reginae
Albizzia lebbek
Cedrela serrata
Calophyllum tomentosum
Phoebe hainesiana
Pinus longifolia
Michelia champaca
Shorea assamica
Abies pindrow
Gmelina arborea
Duabanga sonneratioides
Boswellia serrata
Vateria indica
Cedrela toona
Picea morinda
Bombax malabaricum
Canarium euphyllum
Pinus excelsa
Bombax insigne

(3) Flexibility and toughness.—Flexibility is more or less associated with toughness, but a really tough wood may, on account of its stiffness, be one which could not properly be considered flexible. Flexibility is indicated in tests by the combination of a high strength value with a low value in elasticity. Heat and moisture in combination increase flexibility, and steaming is often employed in the preparation of bentwood products. Young shoots of willows, *Celtis*, *Juniperus*, and ash are very flexible as well as the wood of many climbers.

(4) Elasticity.—Elasticity is the property of matter which enables it to regain its original form and dimensions after deformation, and in the case of bending tests is expressed numerically as Young's Modulus. For practical purposes the results of static bending tests and impact bending tests are combined and used to indicate the 'stiffness as a beam' of different timbers. Those species having the greatest elasticity will stand highest in this list. Elasticity is a property necessary in woods which are to be used for carriage-shafts, bows, sports goods, spars, and the like. The following list indicates the relative elasticity of some of the commoner Indian woods, the two columns to be read successively from head to foot:—

Shorea obtusa
Mesua ferrea
Schleichera trijuga
Heritiera minor
Xylia dolabriformis
Pentacme suavis

Dipterocarpus turbinatus
Grewia tiliaefolia
Dipterocarpus tuberculatus
Anogeissus acuminata
Pterocarpus macrocarpus
Hopea parviflora
Shorea robusta
Parashorea stellata
Terminalia belerica
Terminalia tomentosa (U.P.)
Terminalia paniculata
Terminalia bialata
Pterocarpus dalbergioides
Xylia xylocarpa
Tectona grandis (Burma and Malabar)
Vateria indica
Hopea odorata
Eugenia jambolana
Albizzia lebbek
Lagerstroemia parviflora
Anogeissus latifolia
Acacia arabica
Pterocarpus marsupium
Pentace burmanica
Calophyllum tomentosum
Terminalia tomentosa (Madras)
Artocarpus hirsuta
Dalbergia latifolia
Michelia excelsa
Tectona grandis (Central Indian region)
Abies pindrow
Dalbergia sissoo
Morus alba
Pinus longifolia
Lagerstroemia flos-reginae
Albizzia procera
Phoebe hainesiana
Cedrus deodara
Chukrasia tabularis
Adina cordifolia
Juglans fallax
Shorea assamica
Mangifera indica
Picea morinda
Canarium euphyllum
Cedrela toona
Boswellia serrata
Gmelina arborea
Pinus excelsa
Hardwickia binata
Hymenodictyon excelsum
Lannea grandis
Bombax insigne
Bombax malabaricum

Compression tests

In actual practice the compressive strength of wood is employed either to resist crushing across the grain (compression perpendicular to grain), or to resist crushing in the direction of the grain (compression parallel to grain). Resistance to crushing across the grain is required in rollers, axles, railway sleepers and floor beams. Ability to withstand crushing along the grain is necessary in short struts, mine props, piles, and wheel spokes. The strength of wood in resistance to compression parallel to grain is commonly about four times that in resistance to compression perpendicular to grain, and both vary with moisture content, dry wood being the more resistant to crushing.

Shear

When material is broken by causing one part to slide over another, the failure is called 'shear', and the force which causes it is called a 'shearing force'. Such a fracture occurs when a bolt pulls away the portion of material between it and the end of the joint; leaving a slot from the bolt hole outwards. Wood, on account of its fibrous nature, is not liable to fail by shear across the grain. Its resistance to shear along the grain varies greatly but is much less influenced by the presence of interlocked fibre than is commonly supposed. *Homalium tomentosum*, for example, a typically straight-grained wood, has the highest strength in resistance to shearing of any wood yet tested in India.

The resistance of wood to shear on a radial plane (i.e. along the wood rays), commonly differs from its resistance to shear on a tangential plane (i.e. tangent to the growth layers). The resistance is usually greater on the tangential plane, but exceptions are quite frequent. Contrary to popular belief it does not necessarily follow that the shearing strength of wood with interlocked fibres is greater on the radial than on the tangential plane. The reverse is sometimes true.

Fissility

Fissility, or the property of splitting in the direction of the fibres, is indicated by the results of tests in tension across the grain, and by the cleavage tests still carried out in some laboratories. In both these tests the specimens are pulled apart by a tensile force exerted at right angles to the grain of the wood.

Fissility is most pronounced in straight-grained species which have fairly high elasticity, and is a valuable feature in wood which is prepared by riving for the manufacture of such articles as spokes, shafts, cask staves, and plaited baskets.

Resistance to splitting is largely influenced by the structure of the wood, and interlocked and wavy fibres are characteristic of the species which split with the greatest difficulty. Hardness and stiffness of fibre affect fissility to a less extent than structure. The effect of moisture is variable, some species gaining and others losing in resistance to splitting as the result of seasoning, and this behaviour is not to be explained by the straightness or otherwise of the grain.

Hardness

Hardness of a material is tested by observing the amount of resistance which is offered to penetration by another body. It should not be confused with the property of offering resistance to cutting by edged tools and saws. Though true hardness and resistance to cutting are generally related, there are cases where the latter is greatly influenced by the presence of abrasive mineral deposits in the wood. These rapidly dull the tools, and woods containing such deposits

offer more difficulty in cutting than others which are really harder but which do not contain so much abrasive substance. *Dillenia indica*, for example, contains a relatively large proportion of mineral deposit, and it dulls tools more rapidly and is more difficult to cut than other species which are harder.

Hardness is greatly influenced by the density of the wood, and also by its moisture content, and by the presence of resinous materials. Green or wet wood is not so hard as wood which is properly seasoned. The presence of large quantities of resinous deposits increases the hardness of wood.

Hardness is a useful quality in wood for flooring, mallets, tool handles, engraving blocks and rollers.

The following list indicates the relative hardness of some Indian timbers, the two columns to be read successively from head to foot:—

Extremely hard

Schleichera trijuga
Mesua ferrea
Shorea obtusa
Hopea parviflora
Pterocarpus macrocarpus
Chloroxylon swietenia
Xylia xylocarpa
Acacia arabica
Aegle marmelos
Heritiera minor
Xylia dolabriformis
Anogeissus acuminata
Terminalia tomentosa (Madras)
Anogeissus latifolia
Pentacme suavis
Grewia tiliaefolia
Dalbergia latifolia

Very hard

Terminalia tomentosa (U.P.)
Shorea robusta
Dalbergia sissoo
Hopea odorata
Pterocarpus marsupium
Pterocarpus dalbergioides
Morus alba
Eugenia jambolana
Lagerstroemia microcarpa
Terminalia paniculata
Diospyros melanoxylon

Hard

Calophyllum wightianum
Chukrasia tabularis
Pentace burmanica
Lagerstroemia parviflora
Albizzia procera
Adina cordifolia
Lagerstroemia flos-reginae
Albizzia lebbek
Dipterocarpus turbinatus
Tectona grandis (Burma and Malabar)
Terminalia bialata
Tectona grandis (Central Indian region)
Dipterocarpus macrocarpus
Calophyllum tomentosum

Moderately soft

Mangifera indica
Parashorea stellata
Dipterocarpus alatus
Calophyllum elatum

Soft

Cedrela serrata
Gmelina arborea
Shorea assamica
Phoebe hainesiana
Cedrus deodara
Lannea grandis
Juglans fallax
Cedrela toona
Abies pindrow
Michelia champaca

Very soft

Boswellia serrata
Pinus longifolia
Michelia excelsa
Picea morinda
Duabanga sonneratioides
Hymenodictyon excelsum
Canarium euphyllum
Pinus excelsa

Extremely soft

Bombax malabaricum
Bombax insigne
Cryptomeria japonica

Other mechanical properties

Other tests, such as resistance to torsion, resistance to tension along the grain, nail-holding power, etc., are carried out as necessity arises in connexion with special investigations, but do not constitute a part of the ordinary routine of timber testing. Tests of made-up or shaped articles such as tea chests, tail-skids and wing-spars of aeroplanes, tool handles, and the like, come under the same heading, and are often necessary and yield very important information relating to the practical application of certain species of timber to particular uses.

Other Properties

Seasoning properties

Wood in the green condition contains a lot of moisture, most of which has to be removed before it is fit for use for building, constructional, or other purposes. The process of drying is known as 'seasoning', but even fully seasoned wood is never entirely free from moisture. Wood is a hygroscopic substance, that is, it has an innate affinity for water, and a piece of wood will always go on absorbing or losing moisture according to the temperature and humidity conditions of the surrounding atmosphere. A seasoned piece of any wood contains less moisture

during dry weather than it does during wet weather, and similarly a piece of wood seasoned in a dry climate, such as is experienced in the Punjab, will contain less moisture than another piece of the same wood seasoned in wet localities such as Bombay or Calcutta. By the term 'seasoning' is therefore meant the drying of wood to a moisture content which is in equilibrium with the atmospheric conditions of the locality in which it is, or in which it is to be used.

By the 'moisture content' of wood is meant the amount of moisture present in the wood, expressed as a percentage of the oven-dry weight of the wood, as follows:—

$$\text{Moisture content} = \frac{\text{Weight of moisture in sample} \times 100}{\text{Oven-dry weight of sample}}.$$

Example:—

Original weight of sample	=	37·41 gm.
Oven-dry weight of sample (i.e. weight after sample has been dried in an oven until it loses no more moisture)	=	29·94 gm.
Amount of moisture in sample	=	7·47 gm.
Moisture content ..	=	$\frac{7{\cdot}47 \times 100}{29{\cdot}94} = 24{\cdot}95\%$

The moisture content of freshly felled timber may be as high as 180% or even more, while the moisture content of seasoned wood ranges from about 6% in very dry localities, to about 20% in damper districts.

The moisture content of wood is one of the most important factors affecting timber utilization, and it is regrettable that in the past in India it has been one of the factors to which very little attention was paid. In recent years, seasoning has received more attention, and in Chapter VIII of this Manual the proper methods of seasoning wood have been dealt with at some length. It will be sufficient here, therefore, to confine attention to the seasoning properties of wood in so far as they affect timber utilization.

In the first place, it may be noted that the defects of shrinkage, splitting, surface-cracking, warping, and other seasoning faults, variations in strength, and liability or otherwise to fungus attack (rot), are all closely connected with the moisture in wood. When a piece of wood dries it shrinks, and unless the drying is even throughout the whole piece, stresses are set up which result in splitting, cracking, warping and similar defects. The remedy is to dry the wood as slowly

and evenly as possible, not always a simple matter in a country like India, where the atmospheric conditions vary so considerably at different times of the year. On the other hand, the longer a piece of wood remains in a damp state, the more liable it is to fungus attack, and in the case of perishable woods rapid drying is, therefore, very necessary if protection is to be secured.

Strength is also affected by moisture content within certain limits, and, speaking generally, seasoned wood is always stronger than unseasoned wood of the same species.

It will be seen, therefore, that seasoning plays a very important part in the proper utilization of wood, and the necessity for removing the surplus moisture as expeditiously as possible, without affecting the qualities of the wood, is a problem which concerns the forest officer as well as the timber user.

Partial drying of wood in the forest, which should not be confused with the process of actual seasoning, is sometimes of help when extracting timbers which do not float in a green condition. By the removal of some of the moisture in the wood, there is a considerable reduction in the weight of the wood, and this facilitates the floating of logs or sleepers. Teak is a good example of this, and it is the common practice in Burma to girdle the standing trees of teak by cutting a ring round the base of the trunk, about six inches wide and sufficiently deep to remove the whole of the bark and the sapwood. The girdled trees are then allowed to stand for two or three years before they are felled, and during this period sufficient moisture is lost to enable the logs cut from the trees to be floated with ease. As green teak will not float, the loss of moisture due to the girdling is of vital importance in the extraction of teak from the Burma forests, and similar instances are not wanting in other forests in India.

But in the same way as the *loss* of moisture from wood may be an important factor, so the *absorption* of moisture by wood may sometimes be equally important.

As already explained, a piece of wood seasoned in a dry climate will tend to pick up moisture when placed in damper surroundings, until it reaches the equilibrium moisture content of the new conditions. This absorption of moisture by wood causes an increase in the dimensions of the piece on account of the swelling of the wood, and is nearly as important as the loss of moisture during the seasoning process, as it is the cause of the 'working' or 'moving' of wood after it has been seasoned.

In addition to this hygroscopic absorption of water vapour from the air, wood, if placed in water, may become soaked with water by the penetration of the liquid through the pores and the empty spaces between the cells. In floating operations this may be a serious matter, as timber which is dry enough to float at the start may become saturated with water, or water-logged, as it is usually called, and may sink. In the Himalayas, the floating of some conifer sleepers

for long distances is very liable to this risk. Spruce and silver fir are especially prone to water-logging, but deodar, kail, and chir pine are not so liable. Unsound wood absorbs moisture in this way very quickly, and the floating of timber which has become affected with fungus is attended with considerable risk on this account.

Shrinking and swelling.—As mentioned above, wood shrinks when it loses moisture and swells when it absorbs moisture. Some woods shrink and swell with variations of moisture more than others, and as a general rule denser woods shrink more than lighter woods. Teak is a paragon amongst Indian timbers in this respect, and weight for weight teak shrinks and swells less than any other wood. This is one of the chief reasons for its popularity amongst timber users, who are well aware that the working or moving of teak is slight in comparison with other woods.

Wood being a heterogeneous substance made up of cells of different structure and size, shrinkage in different directions is bound to vary. The shrinkage along the circumference of a log, for example, more commonly known as tangential shrinkage, is the maximum, and is nearly twice as much as the shrinkage in a radial direction. Longitudinal shrinkage, on the other hand, is practically negligible. These facts are taken into account by the experienced joiner and cabinet-maker, who makes allowances for the movement of the wood in accordance with his experience of the kind of wood he is using and the use to which it is to be put. Neglect of these important characteristics of timber results in the misfitting doors and windows, and shrunken panels, so often seen in houses and other buildings in India.

Splitting and cracking.—Hand in hand with the phenomenon of shrinkage go those of splitting, surface-cracking, warping, cupping and all the various types of seasoning defects caused by the setting up of stresses during the process of drying. When wood dries it shrinks, as explained above, and it is this shrinkage which results in the wood fibres separating from one another and causing splits or cracks. To start with, the separation may be so small as to be hardly visible to the naked eye, but when the process continues, the split or crack continues along the line of least resistance, and ultimately may result in a piece of wood being severed from end to end. The extent of separation depends on a variety of circumstances, but, speaking broadly, woods which shrink most are those most liable to excessive splitting and cracking, and round timber splits more readily than timber which has been roughly squared. Rapid seasoning increases the liability to split and crack, and wood felled in the dry season is, therefore, more apt to start splitting than that felled in the rains. The tendency to split also increases with the size of a log or scantling, and the removal of bark too increases the liability to this defect. The structure of the wood itself likewise plays its part, and want of uniformity of structure tends to increase the liability

to splitting. This means that it can be said definitely that some species are more liable to split than others, but as this subject will be dealt with in detail in Chapter VIII, it is sufficient here to mention that *Terminalia tomentosa*, *Quercus* species, and *Shorea robusta*, are examples of timbers which split or crack excessively, while *Tectona grandis*, *Dalbergia sissoo* and *Cedrus deodara* season quickly, with comparatively little splitting or cracking under normal conditions.

Warping.—Any distortion of a piece of wood from its original shape is designated by the general term 'warping'. Warping is generally brought about by unequal shrinkage in different directions. When distortion is by a curvature across the width of a piece of wood it is known as 'cupping', while a curvature along the length or the broad face is called 'bowing'. Curvature in both directions, i.e. across the width and along the length of a piece of wood, is termed 'twist'. Lateral distortion, at right angles to that of bow, is called 'spring'. Cup, bow, spring, and twist are, however, all covered by the general term warp.

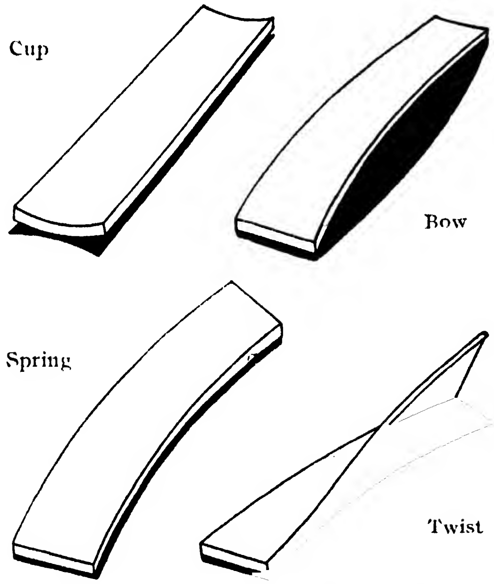


DIAGRAM 1. Four forms of distortion which may occur in sawn timber

Warping may depend on a variety of circumstances, such as the texture of the wood, the part of the tree from which the wood was cut, atmospheric influences and the nature of the species. Generally speaking, woods of even texture warp less than those of uneven texture. For this reason, planks cut in a radial direction warp less than planks cut in a tangential direction, because, in the former case, the annual rings are distributed regularly along the plank and do not

traverse it at various angles. The wood of trees grown in the open warps more than the wood from straight clean forest-grown trees, while the wood of trees with twisted fibre is prone to excessive warping.

As regards atmospheric influences, wood subjected to severe extremes of humidity and temperature is more liable to warp than that kept under more equable conditions. Further, exposure of two sides of a piece of wood to different conditions of humidity will also result in warping. Thus, the wood in plank walls or in panelling is very liable to warp, as the conditions on both sides are seldom uniform. This can be seen in any wooden surface exposed to the sun on one side while the other side is in the shade, or in the panelling of a room where the interior face is exposed to the drying heat of a fire while that on the wall side remains damp and cool. The result is a concave curvature of the panelling on the room side.

As regards the influence of species on warping, no hard and fast rule can be laid down. *Tectona grandis, Dalbergia latifolia,* and *Juglans regia* are all good timbers in regard to warping, while *Shorea robusta, Chloroxylon swietenia,* and *Albizzia lebbek* are examples of bad woods in this respect.

Durability

By durability is usually meant the property of wood to remain sound. It is also sometimes described as the measure of time during which wood remains sound, or in other words the measure of time during which it remains unaffected by the attacks of fungi, insects and other wood-destroying agents. Wood can also fail mechanically through fracture, wear and tear, or continual friction. From a utilization point of view, durability is of paramount importance, and in a tropical country like India, where conditions are often so favourable for the existence and *propagation* of insects and fungi, durability in wood, for most purposes, is a vital necessity. In all the main branches of timber application, such as construction, house-building, railway sleepers, and ship-building, durability is one of the first qualities required, and woods not possessing this essential feature are of secondary importance only, unless they can be artificially preserved.

Durability is, however, a relative term, and a wood that may last for years in a favourable position, such as inside a dry house, may perish within a few months if exposed to moist and warm conditions in an outdoor position. Generally speaking, the term is applied to conditions in which timber is exposed to the forces of nature in an exposed or underground position. Such conditions as those experienced under salt or brackish water or in other positions of a special nature are exceptions rather than the rule. On the other hand, timber kept continuously submerged in fresh water, or in the ground below the permanent level of water saturation, will last indefinitely.

The chief causes of non-durability are fungi (decay or rot), insects (termites, borers, etc.), animals (marine borers, etc.), and mechanical wear and tear. Other minor causes such as humification, when wood is exposed to constant humidity and obtains insufficient supplies of oxygen, or the conversion of wood into peat, need only be mentioned in passing. Fire also destroys wood, but this need not be discussed here.

Fungi.—Probably the worst enemies to the durability of wood are the fungi which cause decay or rot. They gain admittance into the wood by means of spores which germinate in the wood cells and send out minute thread-like growths known as *hyphae*. These hyphae devour the wood-tissues and break down the cell-walls, which causes the timber to become soft and discoloured, a state which in popular language is known as decay or rot. There are very many species of wood-destroying fungi, and their study is beyond the scope of this Manual. It is sufficient to say that they eventually form into a felt-like mycelium which quickly spreads throughout the wood, if conditions are favourable, and eventually reduces it to a soft spongy mass of disintegrated wood-tissue. Rot is not always easily discernible in its earlier stages, but as it progresses, the colour of the wood changes and its specific gravity is reduced. It soon becomes soft and is easily indented with the finger-nail or cut with a knife, and eventually the wood becomes covered with small cracks due to the shrinkage of the tissues attacked, and fruiting bodies or sporophores make their appearance on the outside. Decaying wood in a great many cases also has a peculiar musty odour, which is characteristic of its condition. Among the most common Indian wood-destroying fungi are *Trametes pini*, which attacks only coniferous woods, and *Ganoderma lucidum*, *Polyporus gilvus* and *Polyporus shorea* which attack broad-leaved species.

Insects.—Wood-destroying insects are prominent amongst the many agents which reduce the durability of wood in India. The worst of these insect destructors are the termites, popularly known as white ants, though not related to the ant family. These insects destroy wood by eating its softer tissues and cell contents, and there are very few timbers which can withstand their attacks. There are over a hundred species of termites, amongst the more common being the mound termite (*Odontotermes obesus*) and the house termite (*Heterotermes indicola*). These insects are social and live in colonies, each colony having a queen which is much larger than the rest, and whose sole function is to lay eggs in large quantities. One queen may lay many millions of eggs during the course of her life, which may last for 10 years or more. The multiplication of a colony of termites is, therefore, very rapid, and the adult insects are periodically flying off to form new colonies. They attack dead wood rapidly, taking care never to expose themselves to light more than they can help. If necessary they build up mud

tunnels to cover their movements. Once inside the timber they destroy it rapidly, though never breaking through the surface of exposed wood. There is, therefore, no indication of their presence on the outside, and a sound piece of wood may soon be reduced to a hollow shell without evidence of the damage being visible on the exterior.

Other insects which destroy wood are the borer beetles, which often do as much if not more damage than termites if conditions are favourable for their development. There are many thousands of species of wood-boring beetles, the most important being in the *Bostrychidae* (including *Lyctus*), *Cerambycidae*, *Buprestidae*, *Curculionidae*, *Scolytidae* and *Platypodidae*. Examples of these destructive pests are *Heterobostrychus aequalis*, *Stromatium barbatum* and *Lyctus africanus*, all of which attack seasoned (dry) timber.

Finally, though much less harmful, there are the wood wasps (*Sirex* spp.), the larvæ of which bore tunnels in the dead wood of deodar, spruce and fir, extending for several inches.

Animals.—Amongst wood-destroying animals other than insects, the marine molluscs and crustaceans (*Teredo*, *Martesia*, *Xylotria* and *Limnoria* species) are the most serious. There are many species of tropical and subtropical marine borers, as they are popularly called, of which *Teredo navalis* is a well-known representative.

These animals are provided with two shell-like cutters which revolve slightly in two directions and thus wear away the wood. They do not actually feed on the wood, but they make tunnels in which to shelter from their enemies. They are found only in salt or brackish waters, but as one female may lay as many as a hundred million eggs in a season, and as the young attain maturity quickly, the damage they can do in a short while is tremendous. They are especially virulent in harbours and river mouths, and wooden piers and marine structures are often completely destroyed by these animals, below the high tide mark, within a few weeks.

The *Limnoria*, on the other hand, actually feed on wood and gnaw it with their sharp mandibles. In a short time the wood becomes honeycombed with tunnels, and eventually collapses.

Marine borers are, therefore, a serious menace in tropical waters and have been a serious handicap to the more extensive use of timber for marine, harbour, and river structures.

Mechanical wear and tear.—Other agents in the destruction of wood are mechanical fracture and abrasion. Although not natural agents, they are nevertheless critical factors in the life of industrial timber, their degree of importance depending on the use to which the timber is put. In railway sleepers, for example, durability is dependent, in a great many cases, more on

mechanical wear and tear than on other factors such as fungi and termites. The chief mechanical deterioration in this instance is due to the cutting of the wood by the rail itself, and to the abrasion of the spikes which are driven into the sleepers to hold down the rails. Again, in the case of hammer and tool handles, deterioration is almost always due to mechanical failure of the wood rather than to damage from insects or fungi.

Assuming that timber is sound in the first place, the inherent factors affecting its durability are as follows:—

(1) Moisture content.
(2) Specific gravity and hardness.
(3) Presence of resins, oils, etc. in the wood.

(1) The presence of sap and nutritive materials reduces the durability of wood; hence sapwood is less durable than heartwood. The actual moisture content of the wood is also an important factor in the case of fungus attack, as fungi depend on a certain percentage of moisture for growth, and well-seasoned timber is, therefore, far less subject to fungus attack than green timber.

(2) Although many of the heavier and harder woods are durable, it does not follow that the durability of wood is proportional to its specific gravity and hardness. Hardness certainly repels the attacks of white ants and borers, and in so doing increases the durability of the wood, but no hard and fast rule can be laid down in this connexion. Although the hardness of the sapwood and heartwood of a given species may be identical, the durability of the two may be entirely different in so far as fungus attack is concerned.

(3) The contents and exudations of wood cells affect durability considerably, and the presence of obnoxious or toxic substances such as oils, gums, and resins may keep fungi and insects completely at bay, while infiltration products such as lime and silica may have a deterrent effect on termites and borers. Good examples of increased durability due to the presence of deterrents in the wood are *Tectona grandis*, *Cedrus deodara* and *Shorea robusta*, all of which contain chemical products which are obnoxious, if not definitely toxic, to most insects and fungi.

Finally, there is the use to which the timber is to be put to be considered. Wood always kept in a comparatively dry place, for example in a house in a dry cold climate, would not be liable to decay. Moisture always encourages decay. For example, the ends of beams let into damp masonry are particularly subject to rot on this account. On the other hand, dryness is no deterrent to termites and other insects. Wood will last indefinitely if kept submerged in water (other than sea water infested with marine borers), and a stock of timber which is not durable when exposed to the air can be preserved by submerging it under water until it is required. *Bombax malabaricum*, *Ficus* species, and *Mangifera indica*,

all very perishable woods, have been kept for years under water and have come out at the end as good as the day they went in.

Wood embedded in the ground usually decays rapidly, and the presence of organic matter in the soil encourages decay. In mines, cellars, and other damp places with little air ventilation, wood is particularly liable to decay, and with timber partly in the ground and partly out of it, as in the case of fence posts and telegraph poles, decay is most severe at the ground level, where there is repeated alternation of wetting and drying, and consequently favourable conditions for the growth of fungi. Wood lying on the ground, as in the case of railway sleepers, is subject to attack from both fungi and termites. The question as to how wood can be rendered more durable by the use of preservatives will not be discussed here. It is fully dealt with in Chapter IX.

Classification of woods in order of durability

As explained above, the durability of any species will depend to a very large extent on the use to which it is put. The following list of woods in order of their durability is based on experiments carried out at Dehra Dun in the test yard of the Forest Research Institute, where the annual rainfall is in the neighbourhood of 100 inches. The trials constitute a record of untreated timbers (the test pieces were 2′ × 2″ × 2″) placed vertically, half in the ground and half out, in a locality in which termites and fungi abound.

The test is, consequently, very severe, and constitutes most favourable conditions for quick decay and termite attack. The average 'life' given, therefore, is probably about the general minimum for the various species tested. Six pieces of each species were used in the test:—

	Species	From	Maximum life	Minimum life	Probable average life
			All rejected in	First rejection after	50% or more rejected in
			Months	Months	Months
	Bursera serrata	Burma	67	55	67
	Shorea talura	Madras	62	55	62
	Terminalia paniculata	Assam	61	54	61
	Terminalia manii	Andamans	61	41	54
5	*Lagerstroemia parviflora*	C.P.	58	38	51
	Eugenia gardneri	Mangalore	50	43	50
	Shorea assamica	Assam	61	46	46
	Dipterocarpus obtusifolius	Burma	45	38	45
	Albizzia stipulata	Bihar & Orissa	44	32	44
10	*Acrocarpus fraxinifolius*	Polachi	44	31	44

	Species	From	Maximum life	Minimum life	Probable average life
			All rejected in	First rejection after	50% or more rejected in
			Months	Months	Months
	Terminalia bialata	Andamans	55	25	42
	Dipterocarpus tuberculatus	Burma	67	38	38
	Terminalia chebula	Burma	67	24	38
	Terminalia procera	Andamans	45	28	38
15	*Castanopsis hystrix*	Assam	38	38	38
	Machilus species	Bengal	42	29	35
	Dipterocarpus kerrii	Burma	38	25	35
	Chloroxylon swietenia	C.P.	46	34	34
	Dipterocarpus macrocarpus	Assam	46	29	34
20	*Crypteronia paniculata*	Assam	46	23	33
	Abies pindrow	Dehra Dun	33	14	33
	Terminalia belerica	Bihar & Orissa	51	22	32
	Mitragyna parvifolia	Bihar & Orissa	51	22	32
	Cedrela toona	Burma	50	21	31
25	*Cinnamomum cecidodaphne*	Dehra Dun	50	21	31
	Pinus longifolia	U.P.	44	14	31
	Anogeissus latifolia	Punjab	31	24	31
	Bischofia javanica	Assam	55	24	29
	Dipterocarpus turbinatus	Burma	38	29	29
30	*Aegle marmelos*	U.P.	29	22	29
	Dillenia indica	Assam	29	20	29
	Quercus lamellosa	Bengal	29	17	29
	Lagerstroemia tomentosa	Burma	29	15	29
	Adina cordifolia	U.P.	45	28	28
35	*Vateria indica*	Madras	28	19	28
	Holoptelea integrifolia	Dehra Dun	34	21	27
	Hymenodictyon excelsum	U.P.	34	21	27
	Casuarina equisetifolia	Dehra Dun	37	18	25
	Mitragyna diversifolia	Burma	38	9	24
40	*Juglans regia*	Punjab	31	7	24
	Albizzia lucida	Assam	46	23	23
	Eugenia praecox	Assam	40	14	23
	Mangifera indica	Bihar & Orissa	33	23	23
	Terminalia pyrifolia	Burma	32	18	23
45	*Stereospermum chelonoides*	Assam	23	18	23
	Planchonia andamanica	Assam	23	18	23
	Machilus gamblei	Hamiltongunj	23	9	23
	Bauhinia retusa	Dehra Dun	38	15	22
	Michelia cathcartii	Bengal	30	22	22
50	*Duabanga sonneratioides*	Bengal	50	21	21
	Polyalthia fragrans	Madras	27	21	21
	Sonneratia apetala	Bengal	21	14	21
	Dipterocarpus griffithii	Burma	27	20	20
	Dillenia pentagyna	Bengal	20	12	20
55	*Diospyros melanoxylon*	C.P.	49	11	19

	Species	From	Maximum life	Minimum life	Probable average life
			All rejected in	First rejection after	50% or more rejected in
			Months	Months	Months
	Diospyros pyrrhocarpa	Andamans	36	11	19
	Alstonia scholaris ..	....	28	14	19
	Swintonia floribunda ..	Burma	18	18	18
	Picea morinda ..	Dehra Dun	40	14	14
60	*Bombax insigne* ..	Andamans	31	14	14
	Anthocephalus cadamba	Assam	23	9	14
	Cullenia excelsa ..	Madras	23	9	14
	Parishia insignis ..	Andamans	21	14	14
	Terminalia chebula ..	Assam	14	9	14
65	*Boswellia serrata* ..	Bihar & Orissa	44	13	13
	Lannea grandis ..	U.P.	13	13	13
	Garuga pinnata ..	Bihar & Orissa	13	8	13
	Bombax malabaricum ..	Dehra Dun	12	12	12
	Cryptomeria japonica ..	Bengal	12	12	12
70	*Cryptocarya amygdalina*	Assam	23	3	9
	Crataeva religiosa ..	Dehra Dun	9	9	9
	Canarium euphyllum ..	Andamans	14	7	7
	Parrotia jacquemontiana	Punjab	14	7	7
	Myristica attenuata ..	Madras	7	7	7
75	*Fraxinus floribunda* ..	Kashmir	29	6	6
	Abies webbiana ..	Punjab	15	6	6
	Acer campbellii ..	Darjeeling	14	6	6
	Sterculia campanulata ..	Andamans	10	4	4

Aptitude for being worked

Wood is a complex material, and one which possesses many different textures and characteristics. It is clear, therefore, that such a substance must require different treatments to bring it to a state of perfection for different uses. The aptitude or otherwise of any species for being worked with machines and tools, and finally brought to a perfect condition for painting or polishing, is, therefore, a matter of importance to those in the joinery and allied trades.

In some cases, timbers which compare most favourably with others in the matter of strength, durability, seasoning qualities and appearance, are found to be practically useless for certain purposes owing to their inaptitude to stand up to high-speed workshop machines, or even hand-working. An example of this can be seen in the woods tried for rifle parts and for bobbins. Suitable timbers for these two uses could no doubt be found in India, if it were not for the fact that they have to undergo most severe handling in the processes of manufacture,

and fail to stand up to the tremendous stresses put upon them when they are being shaped in the high-speed cutting machines. The reasons for which woods fail in their aptitude for being worked are usually among the following:—

(1) Bowing or springing when being sawn.
(2) Tearing during sawing.
(3) Excessive hardness.
(4) Blunting of tools and machine knives.
(5) Badly interlocked fibres.
(6) Alternate bands of hard and soft tissues.
(7) Woolly texture.
(8) Excessive gum, resin, or mineral deposits.
(9) Hard knots.

The cause of some of the above defects lies sometimes in the wrong setting of the tools used, but in the majority of cases the fault lies in the wood itself, and no matter how perfectly a machine may be set or how sharp a tool may be, a good surface cannot be obtained. Timbers difficult to work for various reasons are:—

Quercus lineata
Hopea glabra
Dillenia pentagyna
Aegle marmelos
Terminalia arjuna
Xylia dolabriformis

The following timbers are easy to work under ordinary workshop conditions:

Cupressus torulosa
Gmelina arborea
Machilus macrantha
Canarium strictum
Carapa moluccensis
Pterospermum acerifolium

In addition to the defects in wood already mentioned, some timbers have individual characteristics which make them unsuitable for certain uses. For example, species with excessive resin or oil in the wood are often unfit for use in polished or painted work. Deodar is a case in point, and no matter how many coats of paint are given to some deodar wood, the oil in the wood always exudes through the paint and shows up in discoloured patches. Other timbers are very absorbent, and require a great deal of 'filling' before they can be polished. Examples of this are *Pterocarpus dalbergioides*, *Albizzia lebbek*, and *Cedrela toona*.

Another curious defect in the suitability of an otherwise good wood, is the irritating effect of the wood dust of some species on the nose and throat of human beings. This is experienced with *Albizzia lebbek*, the dust of which from a planing machine is so irritating that it gives one the impression of having a bad cold. This wood has earned for itself the name of 'sneezewood' in some workshops. Another timber with a similar characteristic is *Albizzia procera* and, in a lesser degree, *Parashorea stellata* and *Terminalia tomentosa*. A similar complaint is

sometimes made against teak, but the irritation in this case is not usually very severe.

Another bad characteristic, especially in conifers, is knottiness, and a timber which has many large unsightly knots is not only very difficult to work, but definitely unsuited for certain types of work. Chir pine (*Pinus longifolia*) is renowned for having an excess of large unsightly knots and is often avoided for certain works on this account. Knots and similar defects, on the other hand, may not always be a drawback, as is seen in the case of birds-eye maple (*Acer* sp.), in which the small conical depressions due to parasitic fungi give the timber a very handsome appearance, and do not in any way detract from the timber's aptitude for being worked, unless the small knots are loose, as they sometimes are, in which case care is needed to prevent them from falling out.

Attempts have been made from time to time to devise some means of measuring the aptness or otherwise of woods for being worked with different machine tools. So far, the results have not been very convincing, and the personal element will always play a large part in the opinions expressed on any particular wood. There are also variations within a species, and a wood which is found to finish with a fine clean surface in one part of India may act very differently if grown elsewhere. An illustration of this is the riverain sissoo (*Dalbergia sissoo*) from the United Provinces and some of the plantation-grown sissoo of the Punjab. The wood from the United Provinces and most other areas can usually be planed and finished to a clean surface without undue labour, whereas some of the wood of the same species from irrigated plantations in the Punjab cannot be brought to a clean finish at all, even with prolonged hand-scraping. This is due to the latter wood having coarsely interlocked fibres, which means that the fibres are running in alternate directions at intervals, with the result that the fibres in one band ruck up while those in the adjacent band are being smoothed down.

Combustibility and heating power

By the *combustibility* of wood is meant the readiness with which it catches fire, and having caught fire continues to burn until only ash remains.

The *heating power* of wood is the quantity of heat emitted by a given weight of wood during the process of combustion.

When wood burns, its carbon and hydrogen combine with the oxygen of the air, and pass off as carbon dioxide and water vapour, while the inorganic elements in the wood remain behind as ash. The conditions which affect combustibility do not always affect heating power in the same way, but for the present the two may be considered as one. The conditions affecting them are:—

(1) *The moisture content of wood.*—The drier wood is, the easier it is to light and the more heat it gives out. Wet wood expends a great deal of its heating power in converting water into vapour.

(2) *Anatomical structure.*—The density and porosity of a wood have considerable influence on its burning properties.

A very dense wood burns for a long period and gives out a steady heat, but a very porous wood lights much more readily and burns more rapidly, due to the freer admission of oxygen through the large pores.

(3) *Presence of resins, oils, etc.*—The presence of resins and inflammable oils increases combustibility. The resinous wood of some Indian woods, such as deodar and chir pine, can even be used as torches, as it is highly inflammable. The stump wood of chir pine is especially resinous and in some cases is so impregnated with resin as to be translucent. Such wood is known as *chilka* in Kumaon and is the material from which chir tar is distilled.

The value of a wood for fuel does not, however, depend altogether on its combustibility or heating power. Woods which crackle and emit sparks when burning, and most soft woods, rapidly develop an intense heat of short duration. The wood of chir pine and *Diospyros tomentosa* are examples of this. Other woods may give out an offensive smell when burning, such as *Tamarix articulata* and *Kydia calycina*, while others may emit smoke which causes irritation to the skin and eyes, as is the case with *Rhododendron cinnabarinum*. The woods of *Rhododendron cinnabarinum* and *Pieris ovalifolia* only smoulder and will not even burn with a flame, while sawdust of most species smothers itself and only smoulders with considerable difficulty. It will be seen, therefore, that a wood must be tried for the purpose before it can be said to be fit for fuel. It is not always easy to find reasons for the idiosyncrasies of different woods for fuel purposes, but those in the habit of burning wood, whether for domestic or industrial purposes, can soon determine which woods are suitable and which are unsuitable for their requirements.

The following are considered to be good fuel woods and are used extensively for the purpose in the localities where they occur:—

Acacia arabica
Adina cordifolia
Albizzia species
Casuarina equisetifolia
Ceriops candollei
Chloroxylon swietenia
Dalbergia sissoo
Diospyros species
Dipterocarpus species
Eugenia species
Heritiera minor
Hopea species
Lagerstroemia species
Mesua ferrea
Quercus species
Shorea robusta
Tectona grandis (not for cooking)
Terminalia paniculata
Terminalia tomentosa
Xylia dolabriformis

Some of the woods considered to be bad fuel woods are the following:—

Michelia excelsa	*Bassia longifolia*
Garuga pinnata	*Lannea grandis*
Dalbergia cultrata	*Mangifera indica*
Pieris ovalifolia	*Pinus longifolia*
Boswellia serrata	*Bombax malabaricum*

Calorific value of wood

Various methods are used for determining the actual heating (or calorific) value of woods. The most common is that which measures the quantity of heat generated by a unit weight of wood in oxygen, and is expressed either in calories or in British Thermal Units (B.T.U.). A calorie is the quantity of heat absorbed by a unit of water (one gram) in raising its temperature 1° Centigrade, while a B.T.U. is the quantity of heat absorbed by one pound of water in raising its temperature 1° Fahrenheit. The average calorific value of air-dry wood is about 3,620 calories, and that of charcoal about 8,080 calories, or in other words one kilogram of wood or charcoal will raise the temperature of 3,620 and 8,080 litres of water by 1°C. respectively.

The following is a list of the calorific values of Indian timbers determined at Dehra Dun:—

Serial number	Name of species	Calorific values for completely dry and ash-free materials	
		Calories	B.T.U.
1	*Abies pindrow*, Spach.	4,574	8,233
2	*Acacia arabica*, Willd.	4,870	8,765
3	*Acacia catechu*, Willd.	5,193	9,348
4	*Adina cordifolia*, Hook.	5,140	9,251
5	*Aegle marmelos*, Correa.	4,495	8,092
6	*Albizzia lebbek*, Benth.	5,165	9,298
7	*Albizzia odoratissima*, Benth.	5,199	9,358
8	*Albizzia procera*, Benth.	4,868	8,762
9	*Anogeissus latifolia*, Wall.	4,948	8,907
10	*Artocarpus hirsuta*, Lamk.	5,123	9,222
11	*Bassia latifolia*, Roxb.	5,101	9,183
12	*Bauhinia retusa*, Ham.	5,008	9,014
13	*Bischofia javanica*, Blume	5,239	9,432
14	*Bombax malabaricum*, DC.	4,885	8,794
15	*Boswellia serrata*, Roxb.	4,955	8,918
16	*Butea frondosa*, Roxb.	4,925	8,865
17	*Calophyllum wightianum*, Wall.	4,998	8,997
18	*Cassia fistula*, Linn.	5,164	9,296
19	*Casuarina equisetifolia*, Forst.	4,950	8,910
20	*Cedrela toona*, Roxb.	5,141	9,254

Serial number	Name of species	Calorific values for completely dry and ash-free materials	
		Calories	B.T.U.
21	*Cedrus deodara*, Loudon	5,294	9,528
22	*Chloroxylon swietenia*, DC.	4,539	8,172
23	*Dalbergia latifolia*, Roxb.	5,104	9,188
24	*Dalbergia sissoo*, Roxb.	5,045	9,081
25	*Dillenia indica*, Linn.	5,252	9,454
26	*Diospyros melanoxylon*, Roxb.	4,994	8,989
27	*Dipterocarpus indicus*, Bedd.	5,185	9,333
28	*Dipterocarpus turbinatus*, Gaertn.	5,182	9,328
29	*Eucalyptus globulus*, Labill.	4,962	8,932
30	*Eugenia jambolana*, Lam.	4,834	8,702
31	*Gardenia latifolia*, Aiton	4,661	8,390
32	*Gmelina arborea*, Roxb.	4,763	8,574
33	*Grewia tiliaefolia*, Vahl	5,292	9,525
34	*Hardwickia binata*, Roxb.	4,922	8,860
35	*Hardwickia pinnata*, Roxb.	5,100	9,180
36	*Heritiera minor*, Roxb.	5,145	9,261
37	*Holoptelea integrifolia*, Roxb.	5,258	9,464
38	*Hopea parviflora*, Bedd.	5,078	9,141
39	*Lagerstroemia lanceolata*, Wall.	5,017	9,031
40	*Lagerstroemia parviflora*, Roxb.	4,918	8,854
41	*Lannea grandis*, Eng. (syn. *Odina wodier*, Roxb.). ..	4,933	8,880
42	*Mallotus philippinensis*, Mull. Arg.	4,835	8,704
43	*Mangifera indica*, Linn.	4,610	8,299
44	*Mesua ferrea*, Linn.	5,004	9,006
45	*Michelia champaca*, Linn.	5,068	9,122
46	*Morus alba*, Linn.	4,831	8,696
47	*Ougeinia dalbergioides*, Benth.	5,035	9,118
48	*Picea morinda*, Link	4,967	8,941
49	*Pinus excelsa*, Wall.	4,995	8,091
50	*Pinus longifolia*, Roxb.	5,015	9,028
51	*Populus euphratica*, Olivier	5,014	9,026
52	*Prosopis spicigera*, Linn.	5,003	9,007
53	*Pterocarpus macrocarpus*, Kurz	4,889	8,801
54	*Pterocarpus marsupium*, Roxb.	5,023	9,041
55	*Quercus dilatata*, Lindl.	4,799	8,640
56	*Quercus incana*, Roxb.	4,600	8,280
57	*Quercus lamellosa*, Smith	5,165	9,297
58	*Quercus semecarpifolia*, Smith	4,817	8,672
59	*Schleichera trijuga*, Willd.	4,939	8,891
60	*Shorea robusta*, Gaertn.	5,264	9,476
61	*Stephegyne parvifolia*, Korth. (syn. *Mitragyna parvifolia*, Korth.)	4,086	7,355
62	*Sterculia villosa*, Roxb.	4,890	8,802
63	*Tamarix articulata*, Vahl	4,835	8,704
64	*Tectona grandis*, Linn.	5,262	9,472
65	*Terminalia arjuna*, Bedd.	5,079	9,143

Serial number	Name of species	Calorific values for completely dry and ash-free materials	
		Calories	B.T.U.
66	*Terminalia belerica*, Roxb.	4,972	8,950
67	*Terminalia paniculata*, W. & A.	5,080	9,144
68	*Terminalia tomentosa*, W. & A.	5,210	9,378
69	*Xylia dolabriformis*, Benth.	5,062	9,112
70	*Xylia xylocarpa* (Roxb.), Hole	5,010	9,018
71	*Zizyphus jujuba*, Lam.	4,878	8,782

Finally it must be remembered that fuel woods require different properties for different purposes. For example, for warming a room a steady continuous heat is required, whereas for baker's ovens and brick kilns, an intense heat is required for a short time. For locomotives, an intense heat is required, but the smoke must be as free as possible of acid gases, as these damage the boilers. *Acacia arabica* and *Morus indica* are both objected to on this account, though they are considered good fuel woods for domestic purposes. Fragrant woods are sometimes burnt for their perfumed smoke and as incense. Examples are: *Cupressus torulosa, Juniperus recurva, Taxus baccata,* and *Santalum album.*

Defects in Wood

Defects in wood include all abnormal conditions which permanently reduce its utility. They may be caused by: (1) abnormal growth, (2) rupture of the tissues, (3) wounds, and it is under these three heads that the numerous types of defects found in wood will be described.

(1) *Defects due to abnormal growth*

Knots.—Knots are portions of branches which have become occluded and enclosed in the wood of the tree stem. When a branch dies, its base is still nourished for several years afterwards, and a callus is formed around it. The longer a dead branch remains fixed to the tree, the longer is the base which later becomes occluded by tissue. When the branch eventually falls off or gets broken off, the portion which remains gradually becomes completely covered by the growing wood around it, and is eventually embedded in the stem of the tree. The basal portion of the branch is definitely connected to the wood around it, but the remainder is usually unconnected with the surrounding wood which grows over and round it without connexion with it. If a plank is later cut through the basal portion, the knot is still part of the wood, and does not become loose when the wood starts to dry out. This type of knot is known as a 'live' or 'tight' knot. If, on the other hand, a cut is made through that

portion of the original branch which has no fibrous connexion with the stemwood, the resultant knot will become loose, when the surrounding wood shrinks on drying, and will eventually fall out. This type of knot is known as a 'dead' or 'loose' knot.

If the branches of a tree are removed when young, only the central part of the mature stem is knotty. In the same way, knottiness is much less if a crop is kept dense in its earlier stages. The results of heavy early thinnings are, therefore, apparent. In broad-leaved species knots do not differ in texture from the wood of the stem to such an extent as is the case with conifers, where dead knots are usually very hard and resinous, and soon become loose when the surrounding wood dries, and fall out. Such knots are a serious defect, especially if the timber is to be cut into planks or scantlings, as they weaken such material considerably, besides increasing the difficulties of sawing and planing. Tight knots, on the other hand, may enhance the value of some classes of wood by improving its appearance. This may be due to the handsome effect of the knot itself, or to the disarrangement of the original lines of the fibres in having to grow round the imbedded branch, resulting in an eccentric arrangement which is often of very pleasing appearance. A good example of the beautifying effect of knots may be seen in the well-known birds-eye maple (*Acer* species) in which the numerous small depressions resulting from the attacks of a parasitic fungus give the wood a mottled appearance of great beauty. Pollarded oak trees often give the same type of wood, the small knots in this case being due to occluded branchlets. Other examples of species which often have good knot figuring are *Dalbergia sissoo* and Central Indian teak.

Generally speaking, however, knots are a serious defect, especially in conifers. For example, the presence of bad knots in railway sleepers, particularly in the areas where the spikes holding the rails are driven in, is sufficient to disqualify a sleeper for railway use, and in most specifications and grading rules the number, size, position and condition of knots permitted or not permitted, is dealt with in detail. In the Northern Group specification for conifer sleepers, for example, only one tight knot, 1″ in diameter, is allowed near the rail seat area, and the largest tight knot allowed in the rest of the sleeper must not exceed 3″ in diameter.

Examples of very knotty woods are *Pinus longifolia, Cedrus deodara,* and *Taxus baccata,* while examples of those species which are usually fairly free of knots are *Dalbergia latifolia, Dipterocarpus* species, and *Calophyllum* species.

Twisted fibre.—Twisted fibre is the result of the grain of the wood proceeding upwards in a spiral manner instead of in a true vertical direction. The twist may be from right to left or from left to right, the former being the most common. It can often be recognized on the stem and branches of a growing tree from a corresponding twist in the bark which is visible externally. The cause

of spiral growth is not definitely known, but research in recent years has disclosed the fact that it is most prevalent in densely settled districts, and is definitely inherited through the seed even when such seed is grown under the most favourable conditions.

Right-handed twist in conifers has also been discovered to be usually a phenomenon of maturity, i.e. it occurs mainly in mature trees. Another curious fact about twist is that different degrees of twist are found in different layers of the stem and it is not uncommon to find left-handed twist eventually turning into right-handed twist in a mature tree.

The results of spiral growth are soon apparent when using the wood, the chief effect being the twisting of the converted timber. This can often be seen in a sawmill when a log is being sawn up, the planks taking up a twisted form before they have left the saw. In cases of mild twist the defect is not serious, but where the twist is severe, the defect may become a very serious matter. This is well illustrated by the twisted chir (*Pinus longifolia*) of Almora district in the United Provinces. In this area many forests are composed almost entirely of trees with bad spiral growth, and in some cases the spirals are actually horizontal. This renders the wood completely useless from a timber point of view, and its only utility is for firewood and the production of charcoal and chir tar by distillation. Twisted chir trees can however be tapped for resin and are so tapped in forests which are within an economic radius of motor roads.

Railway sleepers with the fibres running at an angle of more than 7° across the sleeper are not allowed under the railway specifications for sleepers, and similar rules are found in most timber purchase contracts, while for splitting purposes badly-twisted wood is quite useless. Twist, when it occurs in a serious degree, may, therefore, be set down as a major defect of wood in so far as sawn timber is concerned, but in the case of poles and posts twist is not always a disadvantage as twisted poles are usually stronger than straight-grained poles.

Wavy wood and burrs.—In some species there is a distinct tendency for the fibres to grow in an exaggerated wavy manner, instead of in a true vertical straight line. This waviness is not usually a serious defect, except where strength and fissility are concerned. A slight waviness of fibre is very common and affects the quality of the wood but slightly. On the other hand, waviness may enhance the value of some species considerably by increasing the beauty of the grain, and where exaggerated waviness is present, figured wood of great value may result, such as is often seen in the case of *Terminalia tomentosa* (laurel) and *Tectona grandis* (teak) from the Central Provinces and Bombay.

Burrs are concentrated masses of wood with excessive waviness. They are usually formed by dormant shoots bifurcating and growing individually in concentric layers, which eventually form knotty swellings on the outside of the

stem, often of considerable size. Their origin is rather obscure, but it is generally accepted that they are due, in many cases, to injuries when the tree was young, so that dormant buds, unable to develop into ordinary branches, grew at the expense of the latter and produced masses of contorted tissue. An attack by certain fungi may also result in globular swellings of sound wood being formed on branches and stems, but such swellings later turn rotten when the sporophores of the fungus begin to develop. Burrs are, technically, defects in wood, but in practice they may be of far greater value than the rest of the tree, owing to the exceptionally fine figured wood which can be cut from them, especially if they are sound throughout. Thus the burrs of walnut (*Juglans regia*), *Albizzia lebbek* and *Terminalia tomentosa* have in past years fetched very high prices, but, like many other valuable products of nature, the supply soon became exhausted, and it is now very rarely that large burrs are found, and then more often than not they are unsound, and frequently bear epicormic twigs. Such burrs are less valuable than smaller burrs which are sound throughout.

Constriction due to climbers.—Climbing plants can do considerable damage to trees by so contorting the stem as to make its shape practically useless for commercial purposes. This comes about by the climber growing spirally round a small tree in the first place. As years proceed, the climber grows thicker and stiffer, while the stem round which it has wound itself is also growing. The result is that the climber is unable to loosen itself from the tree, and as the latter expands in girth, the climber is forced so tightly against it that it is eventually grown over by the expanding tree, until it is finally embedded in the stem, resulting in a bole which has a deep spiral groove running from bottom to top. Amongst the most common climbers which attack forest trees in this way are *Bauhinia vahlii*, *Strathalobus roxburghii*, and *Ficus* spp.

Other climbing plants start from seeds dropped by birds in crevices and branch cavities on mature trees. These germinate and throw out roots which grow downwards over the stem until they reach the ground. The plant then increases rapidly in size and often eventually envelops the host tree and kills it. Examples of this type of pest are *Ficus bengalensis* and *Ficus religiosa*. A third type of climbing plant is that which climbs by clinging on by means of tendrils or prickles. Examples of this type are *Rosa moschata* and *Acacia pennata*. Such climbers do not do damage to the wood of the trees they climb up, but they do affect their shape and development.

(2) *Defects due to rupture of tissues*

It has already been explained that wood shrinks when it dries and that this shrinking causes a rupture of the wood tissues resulting in splits and cracks.

These ruptures, known as shakes, are definite defects in wood, and for ease of reference are usually classified under the following heads: (*a*) Heart and star shakes, (*b*) Radial shakes, (*c*) Cup or ring shakes.

Heart and star shakes.—A simple heart shake consists of a crack starting at the pith and extending outwards towards the periphery in a radial direction. Even though the crack runs across the pith and extends in the opposite direction it is still a simple heart shake. If there are more than one such cracks radiating from the pith, the defect is known as a compound heart shake or star shake.

Heart shakes are usually visible on the transverse section of a log soon after the tree has been felled. They are usually caused by the rapid drying of the centre tissues of the stem round the pith. This may be brought about by these tissues having dried out to a certain extent while the tree was still standing, owing to a shortage of the water supply. Very old trees and those growing on unfavourable soils are especially liable to this defect. Heart shakes may also be the result of shock, when the wood tissues round the centre of the tree are ruptured by another tree in falling, by the action of wind, or when the tree itself is felled. After a heart-shaken tree has been felled the shakes tend to extend rapidly, owing to the quick drying of the centre portion of the log resulting from the entrance of air into the existing shakes. In any case, heart shakes are usually the result of some inherent weakness or original defect in the wood before seasoning begins, but subsequent drying rapidly aggravates the defect.

A simple heart shake, even though it extends through the pith, does not reduce the value of a log much for sawing purposes, as a cut can be made through the crack, but a bad compound or star shake is far more serious and may reduce the value of a log considerably.

Heart shakes are very common in old trees of *Tectona grandis* and *Anogeissus latifolia*.

Radial shakes.—Although heart shakes are in a sense radial shakes, the true radial shake is that commencing on the outside of a stem or log and running in a radial direction towards the centre. Such shakes may be only a fraction of an inch in depth or they may run right through to the centre, and across it to the opposite side of the log. In the latter case they become compound radial and heart shakes, and in some species compound radial star shakes are not uncommon. Radial shakes are usually caused by the shrinkage of the outer tissues at a greater rate than the inner tissue, resulting in a rupture of the periphery, and the formation of a crack which extends inwards in proportion to the extent and rate of the difference in drying of the outside and inside of the log. Slow and even drying is the remedy, but this is not easy to attain. Radial shakes may be accelerated by the action of frost or by sudden and excessive heat, such as a hot sun after a cold night, blasts of hot winds, or

PLATE III Section of a log, showing radial, heart, and ring shakes

Facing p. 42

forest fires. They may also be aggravated by strong winds which cause the tree to bend, and result in such radial shakes as exist extending further up the stem. Trees which split easily are more prone to this type of damage than others.

From a sawyer's point of view a single radial shake is not a serious defect, as a saw cut can be made along the crack, but where several radial shakes are present, the defect may reduce the value of a log considerably, as it may be impossible to saw planks from such a log without cutting across one or more radial shakes.

In the plywood and veneer industries, such shakes are more serious still, as in this case the logs are usually cut in a rotary manner, and every radial shake appears repeatedly as a rupture in successive sheets of veneer as the log rotates. Most species are liable in a greater or lesser degree to radial shakes, *Terminalia tomentosa*, *Anogeissus latifolia*, *Bassia latifolia*, *Cinnamomum* species and *Dillenia* species being especially prone to this defect.

The remedy, as in the case of other types of shakes, is slow and even drying, but as the seasoning of logs is always extremely slow, and for practical purposes almost negligible, it is better to convert all logs as soon as possible after felling. If this is not practicable, covering or sheltering the logs from the hot sun and winds retards drying, as does also leaving the bark on, and smearing the ends with a coat of heavy tar, pitch, or some other bituminous material, or even with a mixture of cowdung and mud.

In the case of very valuable timbers of small size, a practice known as radius-cutting is sometimes made use of. This consists in making a radial saw cut from the periphery to the pith along the length of the log. This cut frees the stresses round the circumference and the cut opens to a wide V, thereby saving many other radial shakes. This practice is commonly resorted to in the case of *Buxus sempervirens*, and most boxwood logs are radially-sawn soon after felling.

Cup and ring shakes.—Cup and ring shakes are formed by the rupture of the tissues in a circular direction round the tree or log, usually along the annual rings. When the rupture extends only a part of the way round, it is termed a cup shake, but when it extends the whole way round it is known as a ring shake. Complete ring shakes are not very common, and it is more usual to see several intermittent cup shakes in a log rather than one complete ring shake.

Cup and ring shakes may be caused in various ways such as the shrinkage of the central tissues owing to shortage or loss of moisture, the action of frost, fire, animals, or other forms of injury to the cambium, or by a shock produced when the tree is felled, or when another tree falls against it, or even by the action of a high wind or electric storm. Cup shakes have also been known to follow

defoliation by caterpillars, which severely checks the nutrition of the tree, resulting in the new wood failing to adhere to that of the previous year.

The effect of cup and ring shakes on the utility of a log depends to a large extent on the size, number and position of the shakes. The effect of a small cup shake can often be obliterated by discrete sawing, but a log in which there are several cup shakes of varying size is much reduced in value, and if these shakes are combined with heart and radial shakes, a log may be rendered valueless except as firewood.

There is no real remedy for cup shakes as they are mechanical defects inherent in the wood prior to felling. They can be aggravated by rough handling of the log and by too rapid drying, but they cannot be prevented. In a great many cases they are surface wounds which have been grown over and occluded, and although the rupture of tissues may not be very apparent, it is there nevertheless, and is a definite weakness in the wood which will become more evident as the wood dries.

Examples of species prone to cup shakes are *Quercus dilatata* and *Quercus incana*, while soft woods like *Bombax malabaricum* and *Sterculia campanulata* seem to be exceptionally free from this type of defect.

(3) *Defects resulting from wounds*

Pruning.—However carefully a branch may be pruned, the new wood which grows over the cut never joins completely with the cut surface. This means that there is a flaw in the wood which may not be serious in the first place, but which will have a weakening effect on the wood and may be the starting-place of a shake. The pruned surface is also a point of entry for fungi and insects and may, therefore, result in a deterioration of the wood through these causes. The tarring of pruned surfaces may help considerably to prevent such damage, but the danger is always present.

Broken branches.—The risks in this case are the same as for pruned branches but more serious, as when a branch is broken off the broken surface presents better opportunities for fungi to develop. In addition, the wound takes much longer to heal than a clean cut, so that risk of infection is prolonged, and there is no tarring to retard or prevent it. Broken branches also result in loose knots being formed and these, if numerous, are a serious defect in any wood.

Fire.—As a general rule damage to the *wood* of trees by fire is not serious unless the fire is of such intensity as to set the stem of the tree alight, in which case the damage may amount to the total loss of the tree. Such fires are very rare in broad-leaved forests but are not infrequently seen in coniferous forests. Some of the fires which rage in the coniferous forests of North America are

witnesses to the immense damage that a serious fire can do, but fortunately, in India, such fires are rare, and those that are met with most commonly are ground fires, which may check the growth of the trees severely and may even kill them, but which seldom completely burn them.

The damage resulting from such fires usually consists in a scorching of the bark, and this may or may not continue through to the wood. If the cambium layer is damaged a definite rupture between the old wood and any new wood that may form, occurs, and if the damage is complete round the base of the stem, the tree will usually die.

In any case, a wound of any kind on the surface of a tree is a danger spot, and may be the starting-point for fungus attack, or, if the wound is deep, may result in the formation of shakes and loss of strength in the wood.

Animals.—Damage to the wood of trees by animals (other than insects and marine borers) is not usually serious except in retrospective effect, such as when young crops sustain damage which later affects the mature crop. Damage to mature trees is usually the result of wounds caused by deer, bears, and other animals which peel off the bark and destroy the cambium layer, thereby creating a rupture between the old and new tissues, which means a loss in strength and a starting-point for shakes. Elephants sometimes damage mature crops by breaking branches and even overturning fairly large trees, but such damage by animals is more of silvicultural than utilization importance. Woodpeckers can do severe damage to individual trees, not only by boring their nesting holes but also by making an entry for the more harmful fungi, but usually a woodpecker will only attack a tree which is already dying or dead.

Insects.—Damage to wood by insects may result in very serious defects in the wood from a commercial point of view. Such damage may be done when the tree is still living or may take place when the tree is dead, or even after it has been felled and converted.

The insects which affect the commercial value of timber most prior to its being used are wood borers. Termites are great destroyers of wood when it is in use, but the damage they do to standing trees, logs, and converted timber, if properly looked after, is negligible compared to that done by boring beetles.

Insects which bore into living trees in the adult or larval stages are difficult to cope with. It is possible, sometimes, by studying their life history, to discover some means of trapping them or destroying them at certain periods of their existence, or by altering circumstances in the forest to make conditions for their existence unfavourable, but such methods are not always practicable, and the damage done by this type of insect in India is still very large. Birds are very beneficial in this connexion as they destroy large quantities of harmful

insects during their search for food. Woodpeckers, nut-hatches, tree-creepers and similar birds are especially useful in this connexion, and every endeavour should be made to protect them.

The presence of harmful insects in a living tree is not always easy to detect, but if the small entrance holes are observed or the exudation of the powdered borings is seen, it is a certain indication that the harm has started. The number of different species of these tree-boring insects is relatively few, but some do damage of enormous economic importance while others are more or less of academic interest only. Amongst the best-known of these stem-boring insects are *Xyleutes ceramica*, popularly known as the bee-hole borer of teak, whose larvæ bore large tunnels in sound teak trees in Burma, often rendering the wood unfit for use, and *Hoplocerambyx spinicornis*, a major borer which attacks sal trees, and often does considerable damage to the wood.

Amongst the second class of boring insects, namely those which attack dead wood, there are many which do considerable harm to the wood they attack. The procedure of attack is either by the insects laying their eggs in or under the bark, whence the larvæ bore into the wood, or by the mature insects themselves boring into the wood in order to lay their eggs. In some cases the insects will bore well into the heartwood of sound logs before they deposit their eggs. In the case of those insects which lay their eggs in the bark, the removal of the bark will always effect a remedy, and where damage of this kind is feared, the removal of the bark immediately after a tree is felled always prevents attack. On the other hand, the removal of the bark of some species results in excessive cracking and splitting of the logs, and the question as to which form of damage is likely to be more serious is often a matter for consideration. In any case, such timbers should be removed from the forest at once and converted as soon as possible, while storage in water is an excellent way of preventing both forms of damage, if early conversion is not practicable.

For those insects which bore into the wood in order to lay their eggs, methods of prevention are not so easy. Water storage prevents attack, but is not always available, and the best solution is early conversion and rapid seasoning, followed if necessary by preservative treatment. The storage of wood under creosoted or otherwise-treated sawdust can be profitably adopted in some cases, while spraying with preservatives is often effective as a preventive measure. The presence of borers in logs or converted material is discernible from the entry holes and the boring dust which is ejected. Very often the insect can be heard working in the wood. Once any of these signs become evident it is too late to adopt preventive measures, and the only remedy is to stop further damage by steaming the wood at a temperature of 180°F. or over, or by preservative treatment in a pressure cylinder. Either measure will kill the insects and eggs, while thorough

preservative treatment will prevent further attacks. If the damage is very bad and the value of the wood has already been greatly reduced, it is often best to destroy the wood by burning in order to prevent the spread of further attacks to other sound timber. The effect of borer damage is to reduce considerably the strength of the timber attacked. In addition, its appearance is greatly impaired, and for such work as cabinet-making and joinery, insect-attacked wood has little value. Even if the attack has been slight and completely checked, timber buyers are very shy of purchasing wood which shows any signs of attack, as they cannot be sure how far the damage extends beyond that visible to the eye.

It is better, therefore, to offer clean wood only rather than run the risk of reducing the price of the whole, by displaying even a small proportion of insect-attacked wood. Not infrequently, attack is confined to the sapwood only, and by cutting off the sapwood, clean timber is obtained, but unless this fact is well known to the buyer, he is usually suspicious, and not so likely to offer the same price as he would if the heartwood was clear of attacked sapwood.

This second group of wood-destroying insects is very large, and the number of species they attack is also very great. Evidence to this effect is visible to anyone who visits the entomological museum of the Forest Research Institute at Dehra Dun, where damage by many hundreds of the more harmful Indian wood-boring insects on many different species of woods is artistically displayed. Amongst the most important of these insects, from an economic point of view, are the well-known death watch beetle (*Anobium pertinax*) fortunately not found in India, shot-hole and pin-hole borers, longicorns, weevils, and powder post beetles. The last-named family contains *Lyctus africanus*, a very common Indian pest which has been found on many species of timber.

Bamboos also are very subject to attack by boring beetles. The most common insects in this respect are the bamboo shot-hole borers (*Dinoderus* species), commonly known as *ghoons*, which riddle bamboo culms with their minute borings within a few months of felling, if conditions are favourable.

A bamboo thus attacked is rendered valueless for many purposes, and the Ordnance Department will not pass any bamboo for lance shaft work if there is a sign of the presence of shot-borers. Investigations on the subject have revealed the fact that these insects feed on the starch in the bamboo tissues, and that if no starch is present, the chances of a serious attack are slight. By soaking the bamboos in water, preferably running water, the starch is largely removed, so that water-soaking is a useful preventive, while felling during the cold weather (especially during the months of December, January and February) reduces the liability of attack. Soaking in Rangoon oil also helps to prevent attack, whereas treatment with creosote oil and other preservatives definitely prolongs the durability of any bamboo.

Parasitic plants.—The effect of damage by parasitic plants is not serious, since the attacks of such plants are usually confined to the branches and upper parts of a tree. The wood they do attack is itself seriously damaged, owing to the plants sending out *haustoria*, or root-like growths, which penetrate the wood, thereby weakening it, and rendering it more or less valueless. The area of attack is, however, usually small and cannot be considered as serious. The plants concerned belong chiefly to the order *Loranthaceae*, the most common being *Loranthus longiflorus* which grows on *Albizzia, Bauhinia, Bassia, Buchanania, Diospyros, Heritiera* and other species; *Viscum album*, the well-known mistletoe, found on *Juglans, Ulmus, Salix, Populus, Olea, Morus* and other species; and *Loranthus vestitus* which is extremely common in parts of the Himalayas, on *Quercus incana, Quercus dilatata*, and other oaks. It grows also on *Lannea grandis*, and *Schleichera trijuga*.

Fungi.—The defect of unsoundness in wood is due to the action of fungi. The subject has already been discussed under Durability (p. 27) and we are only concerned here with the defect in so far as it reduces the value of timber.

It has already been explained that the hyphæ of wood-destroying fungi penetrate into wood by threading their way through the cell-walls. In so doing, they absorb cell-wall tissue, and this naturally weakens the cell-wall itself in proportion to the severity of attack. A few fungal hyphæ would not appreciably affect a piece of timber, but unfortunately, the growth and extension of hyphal threads is very rapid, and unless they are checked in the very earliest stages, they soon disintegrate sufficient cell-wall area to weaken appreciably the whole wood structure. If the attack continues, the wood loses its strength, rigidity and hardness, and eventually becomes an amorphous mass of disintegrated tissue. When it has been reduced to this state it is useless, even for firewood. Fortunately, fungal attack is very often local, to start with at any rate, and if detected in time can be stopped, thereby saving such wood as has not been attacked. This can be done by steaming the wood at a temperature of 120°F. or over, when all fungal threads, mycelia, and spores will be killed. If an attack is more general, the same remedy will apply, but in this case the timber as a whole will be affected, and even though the attack is checked, the strength of the wood will have been reduced and its market value lowered.

Fungus attack is not always easy to detect in its early stages, and it is more difficult to detect in standing trees than it is in logs or converted timber. If a tree shows signs of stag-headedness or has broken dead branches, holes in the stem, or signs of canker, blistering, or an abnormal flow of resin or gum, it is a fairly sure sign that decay is present. If the tree gives a dull soft sound when struck with the back of an axe, decay is in an advanced stage, while a hollow sound indicates that there is a cavity in the stem, probably in the centre, which

means the middle portion of the tree is unsound, whereas the outer portion may still be unaffected. In all cases the tree should be felled as soon as practicable on the chance of there being a good proportion of sound wood.

In logs and converted timber the detection of decay or unsoundness is a simpler matter. The ends of logs can be examined for hollows, or suspicious softness, colouring and odour, while the log can be hammered along its length in order to test it for the presence of hollows or decay.

In the case of converted timber, discoloration is the surest sign of fungus attack, while a close examination and testing of the hardness of the wood with a knife will soon indicate whether the damage is severe or not.

It should, however, be noted that discoloration by itself does not always mean that the timber is attacked by a *wood-destroying* fungus. There is a common phenomenon in wood known as 'sap-stain' or 'blue stain', which, although resulting from the attack of a fungus (*Ceratostomella*), is not serious, since the mechanical properties of the wood are not greatly impaired. The reason for this is that the hyphae in this case do not destroy the walls of the wood cells, but penetrate through them by means of the pits and intercellular spaces. The strength of blue-stained wood is, therefore, very little affected by the fungus, and, except for the presence of the unsightly discoloration, the wood value is not reduced. There are other stain-producing fungi, causing yellow, red, and greyish discolorations in wood, but they are not common, and are not so frequently met with as the blue stain frequently found on Indian woods.

II

FELLING AND CONVERSION

Implements Used in Felling; axes—saws. Season for Felling. Methods of Felling; general rules—felling with axes and saws—felling by the roots—labour—roping. Conversion of Timber; general remarks—logging—squared timber, or rough conversion in the forest—hand sawing—types of saws—description of hand-conversion of scantlings, etc.—description of converted timber—railway sleepers—where the forest goes—machine sawing—markets—grading.

Implements Used in Felling

Axes

In India, felling axes cover a wide range both in size and shape. Most types possess some advantage or other, and each type is no doubt considered to be the best by the man accustomed to use it.

The chief purposes for which axes are used are: (1) felling, (2) trimming, (3) splitting, and (4) grubbing; and for each of these purposes a different type of axe is used, though most felling axes can, if necessary, be used for all purposes. Nevertheless it is not so much the axe as the skill of the man who uses it which is necessary to obtain good work.

Description of felling axes.—Axes consist of two parts, the metal head and the wooden handle. The axe head carries a socket called the eye, into which the handle fits. The portion of the head in front of the eye is known as the blade, and that on either side of and behind the eye, is known as the back of the axe.

The axe head.—The best type of axe head is either a solid piece of iron with a steel edge welded on to it, or two tapering pieces of iron between which a narrow wedge of steel is introduced. This projects slightly beyond the two pieces of iron to form the edge. Steel permits of a sharper edge being ground and is more durable than iron.

The edge of the blade should be sharp and of the proper temper, neither too soft, in which case it would bend, nor too brittle causing it to chip. As regards the shape, the blade should be in the form of a tapering wedge; preferably the sides should be slightly convex in front of the eye as this reduces friction and renders the head less likely to stick in the cut. In addition, this has the effect of accumulating the weight just in front of the eye, and this gives the best balance.

The edge of the blade should be slightly curved: this produces better penetration and renders the corners less liable to break off. With regard to weight, it is useless for a man to try and use an axe heavier than he can manage, and most tools manufactured for European labour are far too heavy for Indian axemen. Fellers in the Himalayas still prefer their own pattern axe to the American wedge pattern which has been freely offered to them.

Among Indian axes, the Malabar axe, which is extensively used on the west coast of Madras for felling large trees and for rough-squaring logs, needs special mention. It consists of a wedge-shaped head fitting into a hole in the handle. The hole is rectangular in shape tapering towards the back, and is strengthened by two iron rings shrunk on the handle, one above and one below the hole. The handle is slightly curved, round at the upper (axe-head) end and oval at the lower end. A particularly heavy broad-bladed axe is used for squaring logs in the Himalayas, where the workman stands on the log and lets the weight of the falling axe do most of the work.

The axe handle.—In India, round handles fitting in round eyes are almost always used. Round handles are easily made and fitted; and should a handle break, it can be replaced on the spot by cutting a solid bamboo or a straight piece of tough wood. A disadvantage is that round handles are liable to slip round in the eye. European and American axes usually have oval-shaped handles and eyes. In this case, the handle cannot slip round in the eye, and allows a thinner and more tapering blade to be used. That part of the handle which fits into the eye is split, and a tight fit is obtained by driving in a hard wooden wedge between the two sides. This is the method which should always be adopted in fitting tool handles with metal heads. It not only holds good with axes, but also with other tools like pickaxes, hammers and Indian hoes. Wetting the wood round the axe head also helps to obtain a tight fit, as the wood swells and automatically tightens the fit. European, American and Malabar handles are not straight but are curved in a way that aids the grip of the handle, and improves the balance of the whole axe when it is being swung. The chief disadvantage of these handles is that they cannot be replaced easily unless spares are kept in stock. They are, in addition, rather liable to break just below the eye when used by labour unaccustomed to them, but in the hands of experts the cut and power of axes fitted with such handles is tremendous.

Diagram 2 shows an American felling axe and a number of types of Indian felling axes, each of which is popular in its own district.

Billhooks may be mentioned here as tools often used for felling bamboos and small poles and for cutting brushwood, though they are not strictly felling instruments. They exhibit great variety of shape, each type being preferred in the locality where it is used. There are numerous tools used in India which

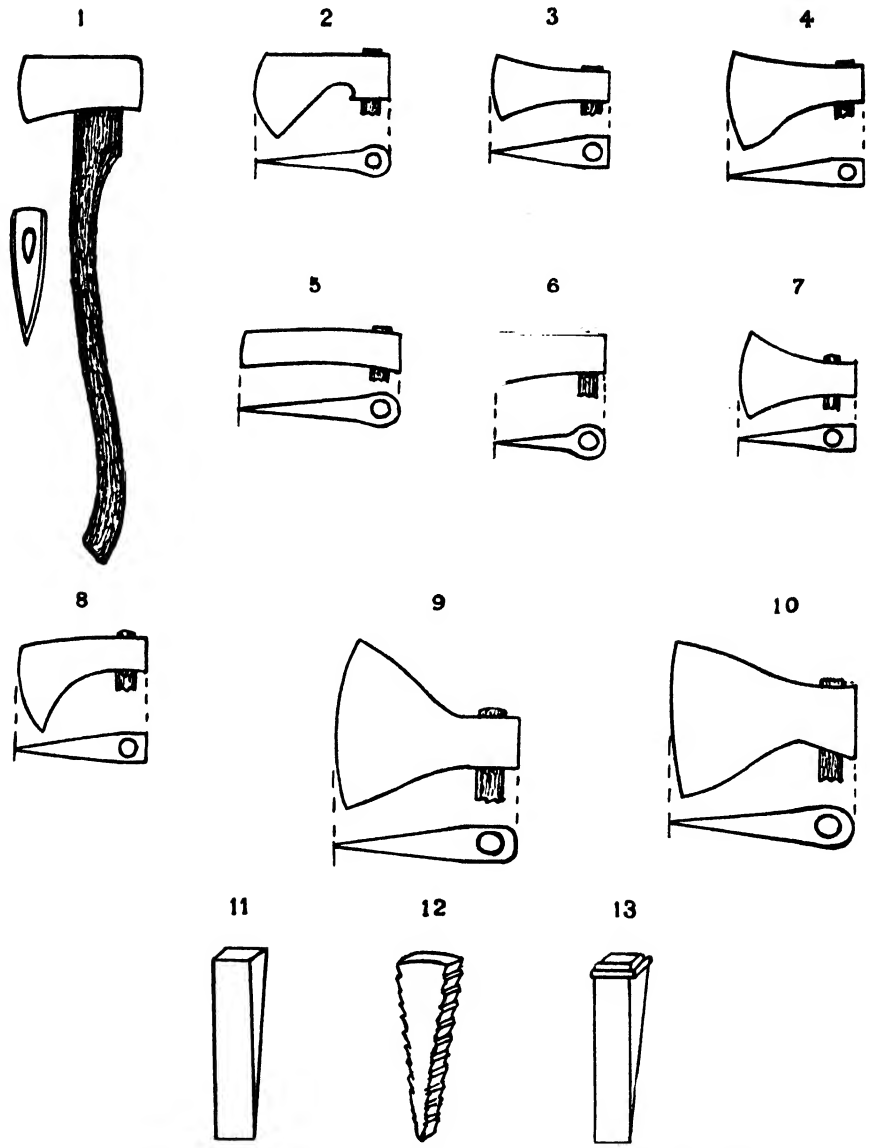


DIAGRAM 2. Implements used for felling, *one-tenth natural size*

1. American axe
2. Pahari axe, Garhwal
3-4. N.-W. Himalayan axes
5. Madras type
6. Bombay type
7. Hyderabad (Dn.) axe
8. Kashmir axe
9. Kashmir trimming axe
10. Travancore trimming axe
11-12. Iron wedges
13. Wooden wedge with iron band

correspond to a certain degree to the European billhook. The Burmese ***dah*** and the Nepalese ***khukri*** are two well-known examples.

Saws

Saws are used for felling, cross-cutting and ripping logs into planks, scantlings, sleepers and other classes of converted material. Saws are called two-handed or one-handed according as to whether they are worked by two men or one man. Only two-handed saws can be used for felling except in the case of very small trees or poles. Most types of saws used for cross-cutting felled trees into logs can also be used for felling, but the latter is much harder work, requiring considerable skill, and in order to do felling with a saw full justice, it is well worth while purchasing American felling saws which are specially adapted for this work. The blades of these saws are narrow, about 5″ wide, curved and of uniform width throughout. The back of the blade is also curved, and parallel to the cutting edge formed by the teeth. The chief advantage of this type of blade lies in its lightness and reduced surface friction, which considerably lightens the work, an important point when sawing has to be done in a cramped position as is usually the case in felling. In addition, these saws have detachable handles which can, if necessary, be removed in a second or two. By removing one handle, the saw can be taken out without knocking out the wedges, which is often an advantage. This is particularly the case in hilly country where saws left in the cut when the tree falls are very liable to get broken; and with ordinary saws the fellers have no chance of removing the saw before the tree falls. The handles can be attached to the saws in either a vertical or a horizontal position, which is another advantage. These saws are, however, rather whippy and liable to buckle, so must be used with care. Felling saws can be obtained in various lengths up to 8′ ; they have both 'lance' teeth and 'rakers', as described on page 65.

Different saws are made for cutting soft woods and hard woods, and the correct type of saw should always be ordered. The makers of such saws always have experts on their staff who can advise on such matters.

Season for Felling

In India, the season for felling is mainly determined by climatic conditions. In the Himalayas, above an elevation of about 6,000 feet, snowfall is generally heavy during the winter, and felling is usually done from March onwards, but it may be inadvisable to fell during the rains on very steep slopes, owing to the liability of logs sliding on the soft earth and scoring channels in the ground,

which may lead to erosion. In addition, sliding logs may do considerable damage to the forest they pass through and to themselves. Trees can sometimes be saved from being broken on bad ground by felling them in early spring into depressions and stream beds in which drifted snow is still lying deeply. In the plains and submontane tracts, the working season is chiefly confined to the cold weather, that is from October to March. During the hot weather there is always danger from fire, and water is often unobtainable. Felling in this case, therefore, begins as early as possible after the rains, so that conversion may not be delayed and the coupe may be cleared before the next hot weather begins. In some places, felling during the rains may be possible, and this is all to the good where it can be done. In other cases, trees can be lopped, if lopping has to be done, in the previous winter, so that only the actual felling remains to be done when the rains are over.

The question as to whether winter or summer felling is preferable from the point of view of the effect on the quality of the timber, is one which has for long been a debatable matter. It is not of great importance as it concerns mainly the sapwood, but it is probable that winter felling, when the trees are at rest, is the more favourable. From the point of view of seasoning, it may be taken as a rough rule that felling in very hot dry weather is harmful, as too rapid drying of the logs takes place, resulting in splitting and cracking, but in the case of such species as are liable to rapid fungus attack, rapid drying may be an advantage, and in such cases felling in warm damp weather is to be avoided. Coppice should be felled during the period of rest. This leaves a full growing-season ahead for the young shoots to develop; an important point in localities where frost occurs.

Methods of Felling

General Rules

The felling of trees is an art which is unfortunately insufficiently understood in India. It must be made clear, to begin with, that economic conversion begins with the felling of the tree. However excellent subsequent conversion may be, it cannot entirely make up for the loss of timber resulting from faulty felling. All persons in charge of felling operations should be competent in the theory and practice of felling trees and should have some knowledge of how to use and maintain axes and saws. Good felling requires skill, and it is not a good policy to employ a number of local villagers merely because they possess axes and can cut down trees. The best plan is to keep permanent gangs of trained fellers who can go round the felling areas year after year. If not already trained, they must be taught what is required of them, and both they and the Forest Department will benefit considerably by a little initial instruction. This practice can of course only be followed where Departmental felling is done, but even in

cases where felling is done by the purchasers, it is beneficial to both sides to see that felling is done in the best possible way.

There are two main principles underlying all methods of felling; they are:—

(1) The production of the maximum amount of sound timber which can be made available for export from the forest.

(2) The avoidance of damage to the surrounding forest.

In order to satisfy these conditions the following rules must be observed:—

(*a*) *Trees should be felled as near the ground as possible.* This important rule is to prevent waste of timber, and, in the case of valuable timbers such as teak, is of primary importance.

(*b*) *Trees should be felled in a manner and in the direction in which they will do least damage to themselves and the surrounding forest.* As examples, trees should not be felled across others lying on the ground. Trees should not be felled across boulders nor across sharp depressions or spurs. On hilly ground, it is best to fell trees uphill, since in this direction they have the smallest angle to fall through, and they will fall parallel with the lie of the ground. To do this requires skill, more particularly as trees on hillsides tend to lean outwards and are generally more branchy on the lower side, thereby increasing the tendency to fall that way. Under these circumstances, trees have first to be lopped, and the fall directed by using a rope. Expert axemen in parts of the Punjab can fell large deodar trees on steep ground in such a way that the butts rest on the stumps after the trees have been felled in an uphill direction. Where this cannot be done, fellings should be made in vertical strips and the trees felled herring-bone fashion. If this is done, all trees that start sliding or rolling are held up by standing trees.

Felling along the contour in undulating ground results in the trees breaking their backs and in great damage to the timber. Sometimes it is even best to fell trees downhill, in which case no lopping should be done as the branches form a brake. Although the top of the tree may be broken it is sometimes possible to save the valuable butt log in this way. Felling downhill should however only be resorted to under exceptional difficulties.

(*c*) *Trees should not be felled so that they fall into a place where it is not possible to convert or extract the timber.* If this rule cannot be complied with, it is better to leave such trees standing. Similarly, it is not worth while felling trees which are bound to be smashed to pieces in falling, even when their removal is silviculturally desirable.

(*d*) *Trees should be felled in a manner and in a direction in which they will do least damage to the surrounding crop.* Whenever there is danger of young growth being damaged by felling, as in regeneration areas and selection forests,

trees should be lopped before being felled; the extra cost will always be worth while. A good plan is for the marking officer to have a special sign blazed or written on each tree that he considers should be lopped; climbers should be cut at the time of marking.

(e) *Trees should not be felled during a strong wind.* During a strong wind it is not possible to ensure that trees will fall in the required direction and the work is exceedingly dangerous and should not be allowed under such conditions.

(f) *Felling should usually begin at the top of a slope and proceed in a downward direction.* If felling begins on the upper slopes of a forest, any trees which start to slide down are more likely to be held up by the stems below, as the lower part of the forest will not have been thinned out. If, as is generally the case, conversion follows close upon felling, by starting felling at the top there will be no danger of trees sliding down and damaging previously felled trees, stacks of converted timber or even the sawyers themselves, as would be the case were felling to start from the bottom.

(g) *Fellings should be concentrated as much as possible.* As a rule, it is advisable to divide the felling area into sections, and to distribute these amongst the various felling gangs, so that the work may be kept under better supervision and not allowed to proceed in an uncontrolled way all over the forest.

As a general rule, conversion should keep pace with felling; inattention to this point enhances the danger from fire, theft and insect attack, and as most species are best converted green in India, there is an additional incentive to avoid leaving logs lying in the forest for long periods.

Felling with axes and saws

There are two important methods of felling a tree :—

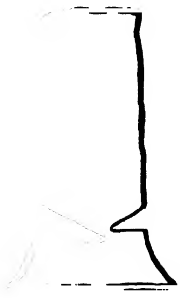
(1) With the axe alone.
(2) With the saw and axe combined.

Felling with a saw alone is seldom used in India.

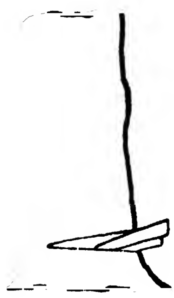
Felling with an axe alone is the more common method employed in India and it is only recently that felling with saws has been introduced. It is not, however, always possible to use a saw; as for instance when trees are growing on the edge of high fields or where the ground below the tree dips suddenly.

The ordinary method of felling a tree is to give an initial cut with the axe on the side towards which the tree is to fall and carry this cut through about two-thirds of the tree. In big trees the initial cut may be as much as three-quarters of the tree. The centre of gravity of the tree must be cut through by the initial cut. The next cut is made exactly opposite to this cut and about 4" to 6" above it. Both cuts must be parallel to each other, otherwise the tree

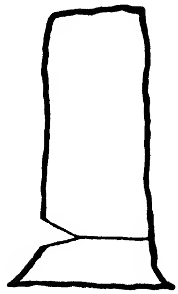
will deviate from the desired direction of fall. Diagram 3 shows how the cuts should be made.



With axe alone



With saw alone



With axe and saw combined

DIAGRAM 3. Methods of felling

When using a saw for felling, a small initial cut is made, low down on the stump and for not more than one-third of the diameter of the tree. An axe is used in combination with the saw to open the cut on the upper side. The outer cut can then be made with a saw exactly opposite the bottom of the initial cut, and as soon as this cut is deep enough, two wedges are inserted and hammered in as sawing proceeds. Unless a rope is used, the fall of the tree is directed by hammering the wedge or wedges which are set opposite the side towards which it is proposed to drop the tree. Using a saw usually saves about 2′ of the butt log, the most valuable part of the tree.

Provided the centre of gravity of the tree is on the stump, the tree can be felled in any desired direction by a manipulation of the cuts and wedges. If the centre of gravity is outside the stump, the tree can be swung through an angle of 30°–45° by manipulating the cut. To attempt to fell a tree in a direction opposite to that in which the centre of gravity falls outside the stump is quite hopeless without a rope.

Felling by the roots

Under certain conditions, such as where a road alignment has to be cleared or where ground has to be cleaned for plantation work, it may be necessary to uproot trees. It is a slow process, except in sandy soils, but it allows of the most complete utilization of the tree. The ordinary method consists in digging the earth away from the roots, which are then severed with an axe as they become exposed. The fall of the tree may be accelerated by the use of a rope.

Felling by the roots is always desirable in the case of very valuable trees. Sandal (*Santalum album*) is a case in point, where roots down to the size of half

a rupee are extracted for the oil they contain. *Khair* (*Acacia catechu*), the roots of which are rich in cutch, is another example.

Many mechanical devices for uprooting trees have been invented, but it is unlikely that they will be of much practical value in India, as they are rather difficult to use, and require skilled labour.

Labour

Two men should not be allowed to work at the same time on one tree with separate axes or saws. This often results in the outer and inner cut being of the same size, so that all control over the direction of fall is lost. One man should fell one tree, except in the case of very large trees; then two men can work on the same cut, but not on opposite cuts.

Roping

It is generally unnecessary to rope trees except where regeneration has to be carefully avoided or on steep ground. On very steep ground a tree can sometimes be held back by two wire cables fixed at the top of the tree and anchored to other trees, standing above the tree to be felled, at an angle of 60° between cables. The tree must never be rocked in order to bring it down. One steady pull should be maintained on the ropes until the tree starts to fall. Any rope used must be long enough to prevent the men pulling from being hit by the falling tree.

Conversion of Timber

General remarks

The conversion of trees in the forest implies the preparation of timber to meet the demands of all classes of markets whether local or distant.

A rough classification of timber in the commercial sense is as follows:—

(1) Timber in the round, or logs.
(2) Roughly converted timber or timber squared with the axe; usually called balks or rough squares.
(3) Sawn timber, such as squares, beams, sleepers, scantlings and planks.

The choice between conversion into round timber or sawn timber depends on a number of considerations, the more important of which are:—

(1) *The demands of the market.* In some localities the whole outturn may be saleable in the form of round timber. In others the demand for logs may be small, or for some special industry only, e.g. for match manufacture or for the production of some special minor product such as cutch and *katha*.

(2) *Availability of skilled labour.* In many localities skilled sawyers cannot be found in sufficiently large numbers, or the locality may be too remote to make

it worth while importing them. It is usually easier to obtain labour for logging than for conversion.

(3) *Sawmills.* If the forests can produce a large and sustained yield of species for which a market exists, sawmills may be justified, in which case extraction would be in the form of logs for conversion in the sawmill.

(4) *The topography of the country.* This is a dominant factor to be considered at the very outset of any extraction scheme, together with the length of lead and the available methods of transport. In any extensive scheme in hilly country, it frequently becomes necessary to work each valley or similar topographical feature as a separate extraction unit, which should be completed before the next adjoining tract is entered. Hilly country generally requires elaborate extraction measures and engineering skill to transport the produce without damage. Thus the species which can be extracted with profit become correspondingly limited in number. Sawing at stump site is frequently resorted to, and the sawn produce transported by manual labour to the nearest carting or floating depot. In the plains, extraction and transport present few difficulties, but in more difficult and remote localities, a careful prior assessment both of the forest potentialities and the cost of production at the sale depots is essential for any proposed scheme of operations.

(5) *Damage to the forest.* With forest conversion large accumulations of slash and refuse are left in the forest, except in cases where a demand exists for scrapwood as fuel. Log extraction may have a beneficial effect, as the soil is wounded during extraction and a minimum of refuse is left behind.

Logging

The work of log conversion consists in trimming off the branches and excrescences from the felled tree and sawing the clean bole, and sometimes large branches, into lengths of the required sizes. The lengths of the logs to be cut will depend on the market requirements and the method of, and facilities for, transportation. For example, there is a limit to the weight of log which can be dragged by animals, or the size and condition of a floating stream may be the limiting factor.

Log lengths should be marked off beginning from the butt end unless, owing to rottenness in the lower part, or crookedness in some part of the bole, more economic conversion can be realized by starting elsewhere. Conversion into logs should always be done with the saw, as cross-cutting with axes is a wasteful practice.

Where logs have to be dragged or extracted down slides or chutes, it is usual to trim the ends, so as to prevent the front end of the log stubbing into the ground during extraction. Where logs have to be dragged, a common practice is to

round off that part of the end which corresponds with that side of the log which gives the best sliding surface. This is called 'snouting'. Where sliding is contemplated, as in most hill forests, the whole of the end is rounded back to about a hand's width. This is called 'snipping'. Unnecessary trimming of any log should be avoided as it leads to waste.

If drag-holes have to be cut in logs, waste can be avoided by cross-cutting the top log so that it includes the base of a branch in which the drag-hole may be cut. Similarly if a tree is crooked, the greatest length of undamaged straight timber is obtained by cross-cutting a few inches into the bend, and cutting the drag-hole in the curved portion. These last two points apply mainly to hardwoods.

A careful record of all converted timber must be made before it leaves the jurisdiction of the exploitation unit, generally a forest range or division. For example, where transportation is by water, it is usual to assemble all the logs at the launching depots first. Methods of recording output may vary considerably, but the general procedure is to give each log a serial number, which is deeply carved into the log by means of a chisel. Any other marks which may be prescribed, such as the year of conversion, property mark, etc., are made at the same time. All the logs are then measured, and the measurements, together with the serial numbers, are entered in lists or registers. In some depots, logs may have to be sorted and classified for sale or royalty purposes.

The following classification of teak logs and poles as used in the Nilambur division of Madras is an illustration of log classification:—

CLASSIFICATION OF TEAK LOGS AND POLES USED AT NILAMBUR, MADRAS

A. Logs

I. Short logs: over 5′ and under 18′ in length, 3′ and above in centre girth under bark

Class	Description	Length	Contents
II. Logs under 2 candies[1]	Fairly straight	18′ and up	9 cu. ft. and under 26 cu. ft.
III. Logs 2–4 candies	do.	do.	26 cu. ft. and under 52 cu. ft.
IV Logs 4–6 candies	do.	do.	52 cu. ft. and under 78 cu. ft.
V. Logs 6–8 candies	do.	do.	78 cu. ft. and under 104 cu. ft.
VI. Logs 8–10 candies	do.	do.	104 cu. ft. and under 130 cu. ft
VII. Logs 10 candies and over	do.	do.	130 cu. ft. and over

[1] One Nilambur candy = 13 cu. ft.

B. Poles

Serial No.	Class	Description	Length	Diameter at $4\frac{1}{2}'$ from base under bark	Centre girth under bark	Contents
1	Measurable	Fairly straight poles	18′ and over	7″ and up	Not specified	Under 9 cu. ft.
2	Superior small	do.	do.	Exactly 7″	do.	Average volume 4·7 cu. ft.
3	I Class	do.	do.	6″ and up but less than 7″	do.	3·5 cu. ft.
4	II Class	do.	do.	5″ and up but less than 6″	do.	2·3 cu. ft.
5	III Class	do.	do.	4″ and up but less than 5″	do.	1·4 cu. ft.
6	IV Class	do.	do.	3″ and up but less than 4″	do.	0·75 cu. ft.
7	V Class	do.	do.	2″ and up but less than 3″	do.	0·46 cu. ft.
8	VI Class	do.	8′ and up but less than 18′	4″ and up but less than 7″	do.	1·1 cu. ft.
9	VII Class	Crooked poles and pieces	5′ and up.	5″ and up	do.	Average volume 1·1 cu. ft.
10	VIII Class	Fairly straight poles and pieces	5′ and up but less than 18′	7″ and up	Less than 3′	Average volume 3·1 cu. ft.

Note:—The pole classes are sold by number, and volume is of no significance to purchasers. The volume given is the average and is to be adopted for statistical purposes in expressing the poles in terms of cubical contents.

CLASSIFICATION OF TEAK LOGS AND SQUARES IN BURMA

Teak logs and squares in Burma are classified (in the case of Government depots) as follows:—

A.1 (*a*) .. Admiralty quality, 16′ and up, 15″ minimum diameter at top and entirely free from standard defects.

A.1 (*b*)	..	Logs under 16′ and entirely free from standard defects.
B.1 or ****	..	All logs 8′ and up, which contain not more than two standard defects, and have a minimum diameter of 15″ at the top end.
B.2 or ***	..	All logs 8′ and up containing three standard defects, and having a minimum diameter of 12″ at the top end.
C.1 or **	..	Logs of all qualities worse than those which would qualify for B.2 with a minimum diameter at top end of 12″.
C.2 or *	..	Logs of all qualities less than 12″ diameter at top end except those classed as D and E below.
D ..	..	House posts. Small straight logs suitable for house posts irrespective of whether they can be classed under the above.
E ..	..	Crooks. Crooked logs suitable for ship-building irrespective of whether they can be classed under any other head.

CLASSIFICATION OF MULBERRY LOGS IN THE PUNJAB

Mulberry logs in the Changa Manga plantations of the Punjab are sold under the following classes:—

I Class (*a*)	..	Length 5′–6′. Girth 3′ and over.
(*b*)	..	do. but which are not butt logs.
II Class	..	Length 5′–6′. Girth 2′–2′ 11″.
Rejected	..	All logs which cannot be classified under II owing to excessive knots.

Fuel

Selected	..	5′ × 2′ 6″ and over midgirth.
Ordinary	..	5′ × 2′ 5″ and under midgirth down to 6″ midgirth at thin end.
Thin	..	5′ × under 6″ girth at thick end and above 3″ girth at thin end.

Logs for export to Europe must be free of all defects and of long length and good dimension. It is useless exporting anything not absolutely first class.

Squared timber, or rough conversion in the forest

Timber can be squared in the forest by means of an axe into balks or rough squares, when a special demand exists for this class of produce or when it is necessary to reduce the weight of the timber to facilitate transport.

Hand sawing

In India conversion of trees in the forest by hand sawing is the most extensively used method and generally competes favourably in cost with machine sawing. It is often the only possible method of conversion. Conversion in the forest may not, however, be the last stage, for some of the larger sizes such as sleepers and beams converted in the forest may, after being sold, be re-sawn into planks, etc. before being finally utilized.

The fundamental object of all conversion methods is the *production of the largest outturn of the best quality timber*. Further than this, economic conversion aims at converting the trees in such a way that the maximum quantity of the more valuable sizes is produced. Some sizes generally fetch higher rates per cubic foot in the market than others, and it can be taken as a general rule that unless this has been taken into consideration, the tree has not been converted to the best economic advantage. This implies a knowledge of how to convert a log to the best advantage, a matter which can only be learnt from prolonged practical experience and which is often neglected as being the job of the sawyer and not of the forest officer.

Various forms of saws and axes are used in converting scantlings in the forest.

Saws.—Saws were formerly made of iron, but all the best saws are now made of steel. Saws consist of a blade toothed at one edge, and either one or two handles, which are attached to the ends of the blade. There are three popular kinds of saws used for felling and logging, the raker or lance-tooth saw, the M-tooth saw and the dog- or V-tooth saw. In logging contests among world champions, no one type of saw has beaten all others consistently, and as yet no one can say which is the best. There are over a thousand different varieties of saws on the market, but they only differ in regard to the size, shape, weight, number of teeth and other minor details. Some definitions of the terms used in describing saws are given below:—

The *face* of the tooth is that edge of the tooth which faces the cutting direction.

The *back* of the tooth is the opposite edge; this does not apply to saws which cut in both directions.

The *space* is the distance from point to point of two adjacent teeth.

The *gullet* is the entire opening between two adjacent teeth.

The *pitch* of a tooth is the angle between the face of a tooth and the line passing through the points of the teeth.

The *set* of the teeth is the extent to which the teeth are bent to either side of the plane of the blade.

The *gauge* is the thickness of the saw blade.

The *kerf* is the width of the cut made by the saw; it varies with the extent of the set.

Action of the saw.—The teeth of a saw act with a combined cutting and tearing action, the latter taking place more in softwoods than in hardwoods, as the looser fibres of softwoods are more easily torn. For this reason more sawdust is produced in the sawing of softwoods than of hardwoods.

Shape of the teeth.—Saws are used for cross-cutting, that is cutting across the grain, and for ripping, or cutting with the grain. In cross-cutting saws, the teeth are made for cutting in both directions. The teeth are either two-edged, or else alternate teeth have their faces on opposite sides. The teeth of cross-cut saws are intended for speed and not accuracy. They are consequently large and have a wide space and gullet, the latter being necessary to hold the large amount of sawdust produced in cross-cutting. Ripping saws have small teeth. These saws usually cut in one direction only and are used where accuracy is required, as when scantlings and planks are sawn from a balk. Whatever use a saw is put to, it is important that the gullet be sufficiently large to allow all the sawdust produced to collect between the teeth until each stroke is finished, otherwise the labour is considerably increased.

Sharpening saws.—If the cutting edge of the teeth of a saw are kept well sharpened, the efficiency is greatly increased. For saws which cut only in one direction, the cutting faces of the teeth should be filed alternately, one on one side and the next on the other side. As all saws used in the forest are 'set', it is always the inner edge of the face which is filed. In the case of cross-cut saws, the teeth are filed on both faces, so that cutting is obtained in both directions. For cross-cut saws, flat files are ordinarily used. For ripping saws, tapering triangular files are best, as the gullet is small. It is of great importance that filing should be done evenly on all teeth and that the teeth should be all of equal length. If the teeth are uneven, the short teeth do not work, while those which are too long are liable to have their tops broken off. Some firms have invented cross-cut saws with perforated blades. The object of this is to ensure that the proper shape of the teeth will be obtained after repeated filing. No definite period can be laid down as to how often saws should be re-sharpened ; this depends on how they are being cared for and on the amount of use they are getting. Ordinarily, saws should not require re-sharpening at shorter intervals than seven days. The cutting edges of the teeth should after filing be as sharp as knives. The principle of filing is the same for all saws, viz. all teeth must be kept very sharp, tooth points must be kept on an even plane, the set should be made even and equal in distance on each side of the saw, and the gullets, which chamber the sawdust, should be kept well open and as near to the saw-maker's original pattern as possible.

Setting saws.—If the kerf of a saw was of the same breadth as the thickness of the blade, the saw would stick fast and refuse to move. Hence it is necessary to cut the kerf wider than the thickness of the blade. This is done by 'setting' the teeth. There are two methods of setting teeth, *spring* setting and *swage* setting. In spring setting, the teeth are slightly bent alternately to one side and the other : this is the method used for all hand saws. In swage setting, the teeth are wider at the points than at the point where they join the blade : this form of setting is ordinarily used only in some machine saws.

With regard to the amount of set to be given, this should never be more than double the thickness of the blade at the base of the teeth. A wider set is necessary for soft woods than for hard woods. Sawyers usually set their saws by giving the teeth a sharp blow with the hammer, the correctness of the setting being tested by placing the saw on a flat surface, such as an iron plate, with its edge bevelled to the proper angle. Various implements for setting saws are in use, and these are essential where valuable cross-cut saws, such as the American 'lance-tooth' saws, are being used. In many places trained saw-filers are maintained. It is very important that each tooth should be given the same amount of set; if this is not done, teeth which are set too much wear down more rapidly and are liable to be broken off.

Types of saws

(1) Cross-cut saws.—These may be either two-handed or one-handed, the latter being used mainly for small work, as in the conversion of firewood and by carpenters. For work in the forest, two-handed saws are generally used. They vary considerably, mainly in the nature of the teeth, the more common types being the dog-tooth, the M-tooth, and the lance-tooth. M-tooth saws are fast cutting, but the American lance-tooth saw is the best. In this saw, two pairs of 'lance' teeth alternate with Y-shaped teeth called rakers. The object of the rakers is to chisel off the strip of wood lying between the two parallel cuts made by the sharp points of the lance teeth, which are set and sharpened in the usual way. The rakers are not set, and as the cutting edge is at right angles to the sawing direction, they cut with the action of a chisel. This combination of two types of teeth results in the most efficient clearing of the kerf and in very rapid cutting.

Modern two-handed cross-cut saws have a convex cutting-edge. This facilitates sawing in allowing for the swing of the arms, and allows the whole of the cutting edge to remain in contact with the surface of the cut at each motion without the sawyers having to assume a cramped position. In addition, it permits of a log being sawn through to the ground with greater facility. With a convex edge there is also more room for the sawdust, as the cut itself is straight

while the saw is curved. Cross-cut saws are now almost always made with detachable handles.

For cross-cutting, the heavier the saw the better, for the weight will do much work. In curved saws, the greatest weight is at the centre, which is just where it is wanted. Cross-cut double-handled saws vary from about $4\frac{1}{2}'$ to $8'$ in length. In using such saws it must be emphasized that the force used must be a pull only. Inexperienced sawyers frequently try to push as well as pull, but this often results in saws buckling and breaking. Saws which break towards one end can often be converted into serviceable saws of shorter length by rivetting the handle on again at the broken end.

(2) Ripping saws.—There are three main types of ripping saws in common use in India for hand conversion of scantlings and planks:

(*a*) The frame saw.
(*b*) The Delhi saw.
(*c*) The pit saw.

Varieties of these saws can be seen in almost any bazaar in India and do not require any but a brief description.

(*a*) *The frame-saw.*—This type is extensively used for hand conversion and is a good implement. It consists of a narrow blade set in a wooden frame to give rigidity. Blades of various lengths can be obtained. This is the universal saw in Himalayan forests.

(*b*) *The Delhi saw* is also a common type. It has a peculiarly shaped curved blade, and can be used for cross-cutting as well, as it is not set in a frame. It is used throughout the United Provinces for cutting sal.

(*c*) *The pit saw.*—These are long heavy saws used when large logs are being converted into beams; they are much in use in South India where sawyers are well-practised in their use.

Requisites of a good saw.—The blade should be stiff and elastic, springing back to its original shape if bent. It should be as thin and as narrow as possible, but not too whippy. It should bend equally at all points. The blade should give a clear ringing sound when struck. To test the temper of the steel, one tooth should be sharply struck to one side with a hammer; if it bends too easily the metal is too soft, while if the tooth breaks it is too brittle. The saw should be well-balanced and the handles should be firmly fixed on the blade.

Care of saws.—When not in use, saws should preferably be hung up by the handles. They should never be allowed to lie on the ground and they should always be greased to avoid rust. When stored in a godown, saws can be laid flat, one on top of another, on shelves, but care should be taken to see that the blades *are* flat and not resting unevenly.

Description of hand-conversion of scantlings, etc.

After trimming off the branches, the tree is cross-cut into logs of appropriate lengths. Taking the thin end of the log, the timbers to be obtained by conversion should now be 'laid out', i.e. marked on the end of the log, after which the log is squared either with an axe or a saw to conform to the timbers laid out. In marking off logs for sawing, every effort should be made to avoid including the heart centre in any kind of beam or scantling and especially in railway sleepers. Railways will not accept such sleepers. Small trees only capable of giving one scantling of sleeper section $10'' \times 5''$ should, therefore, never be converted into railway sleepers. If a line is drawn through the centre of large logs before squaring, it is generally possible to obtain exactly the same number of scantlings devoid of this defect. This necessitates marking the layout of the timbers on the end of the log before squaring, and then adjusting the squaring of the log to the layout. The reverse procedure is often seen in practice, but this should be rigidly discouraged. It is a very common practice to see a log squared first without any regard to what is to be sawn out of it, with the result that timber is wasted and inferior grades are produced. It must be emphasized that all persons engaged in this work of marking off and squaring should make themselves competent in all details. The procedure is that on the two ends of the log the lines delimiting the cross-section of the desired balk are first ruled. Then the longitudinal lines along which the slabs are to be trimmed or sawn down are marked. If the log is to be axe-squared, the *mistri* stands upon it and, beginning at one end, moves down it, cutting off the outside slab up to the line, with downward swings of his axe. As each side is completed, the log is rolled over and another side trimmed. If squaring is done with the saw, the log is rolled over a pit, one man working in the pit, the other standing on the log. These different methods are matters of custom and cannot be changed. Careful and accurate squaring is of great importance, and inexperienced *mistris* should not be tolerated. An advantage of saw squaring is that the side slabs are available for sale where there is a demand for them.

The squared timber is now ready for conversion into the sizes required. The cross-sections of the scantlings which are to be cut have already been roughly marked out on the thin end of the log before squaring. They are now fully marked off, using a ruler, and the external longitudinal lines which the saw-cuts are to follow are shown by tightly stretching a string blackened with wet charcoal powder or other colouring agent. The string is held firmly at both ends and then pulled away from the timber at the centre. On being let go it springs back and leaves a straight black or coloured line as it strikes the wood. The balk is then usually propped up at one end and sawn down the lines, one man working from underneath, the other standing on the log, and by

sawing down the lines, the balk is converted into the sizes required. Trees or logs which are too small to be sawn into scantlings are often converted by trimming with the axe into long timbers of square section. This class of timber often finds a ready market with the poorer class of zemindar for house-building. Another popular form of scantling for the same purpose is made by cutting small logs into four equal pieces, each piece having two sawn sides and one round side. Small-sized sal is often axe-dressed into round 'tors'. In all departmental exploitation the felling, logging, and sawing must be carried out under definite written instructions as to the manner in which every part of the work is to be done, the sizes and the numbers of each size to be sawn, and the method of passing and control. These are local matters which it is not proposed to deal with here.

Description of converted timber

The nomenclature of converted timber is capable of wide interpretation, but broadly speaking, the following are the most common forms of marketable timber:—

(1) Squares or balks. These may be with or without wane.
(2) Beams. Usually rectangular and free from wane.
(3) B.G. and M.G. sleepers.
(4) Scantlings. Square or rectangular.
(5) Planks.
(6) Firewood.

These names are naturally open to wide interpretation and overlapping, and in practice each market has its own sizes and names. For example, the Indian railways call for tenders for 'bottom sides' and 'floor boards', whereas material of the same dimensions would be known as 'beams' and 'battens' in other markets.

To lay down any hard and fast classification of converted material is, therefore, no easy task and is beyond the scope of this Manual. Every forest officer should however make himself acquainted, as soon as possible, with the demands and markets of his own locality.

Railway sleepers

The sawing of railway sleepers is, in India, one of the biggest items of timber conversion in the country. The sawing is usually done by hand, and only in very few instances are sleepers sawn by machinery.

The actual sizes of sleepers used in India vary considerably, especially in regard to length, but the standard sizes for different gauges are as follows:—

Broad Gauge (5′ 6″)—9′ 0″ × 10″ × 5″
Metre Gauge (3′ 3⅜″)—6′ 0″ × 8″ × 4½″
Narrow Gauge (2′ 6″)—5′ 0″ × 6″ × 4″
do. (2′ 0″)—4′ 0″ × 6″ × 4″

In practice, it is customary to cut sleepers about ¼″ or ½″ larger in width and thickness, and a few inches longer than the required size, to allow for loss in shrinkage. In addition to the above sizes, there are 'special' sleepers for bridges and crossings. These are not always of standard sizes, but vary according to requirements from broad gauge lengths up to 20′. Widths and thicknesses may vary too, but not to the same extent.

The shape and size of the tree has the greatest bearing on the output of sleepers. For example, a tree of 21″ diameter will yield two Broad Gauge sleepers, whereas a tree two inches larger will yield three. Diagram 4 illustrates the most economical sizes of logs for sleeper-cutting, and shows the maximum number of Broad Gauge sleepers which can be cut from trees ranging from 14″–30″ in diameter. It will be seen that a few inches in diameter makes a considerable difference in the number of sleepers which can be sawn from a log, throughout the whole series.

Some interesting records are available on the subject of the number of sleepers cut from large trees. In one case, a sal tree in Assam with a girth of 11′ 3″ gave no less than 142 M.G. sleepers, while another tree in the same locality with a girth of 8′ 5″, gave 111 M.G. sleepers. Another case of abnormal production is on record where ten trees gave 782 M.G. sleepers which is an average of 78 sleepers per tree. It is seldom, however, that such large timber-yielding trees are found nowadays.

The cutting of Broad Gauge and Metre Gauge sleepers from the same tree is sometimes practised, and by this means it is often possible to convert a log far more economically than by cutting Broad Gauge sleepers only. It is useless nowadays sawing anything but really good logs into sleeper sizes, as such a practice only leads to increased rejections and differences of opinion between the producer and the buyer. It is generally better to saw knotty logs into other commercial sizes for which a market exists.

The requirement of the Railways in India is in the neighbourhood of 4,000,000 wooden sleepers (all kinds) a year. Against this there is the ever-increasing popularity of metal sleepers. Quality in the wooden sleepers is, therefore, an important feature, if such sleepers are to hold their own with metal, and as the sawing of sleepers affects the quality in no small degree, this subject is one which every forest officer will do well to study, so as to get the best possible output, both in quantity and quality, from the forests over which he holds control. On the other hand, every forest officer should remember that it is more

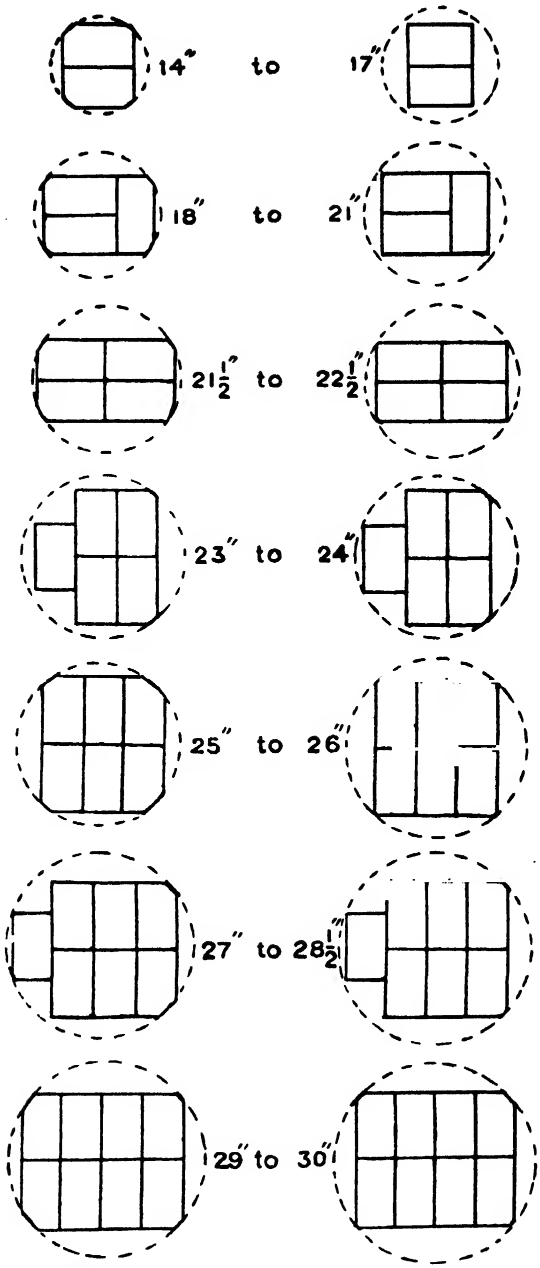


DIAGRAM 4. The method of cutting B. G. sleepers

beneficial to the Forest Department to supply a large number of sleepers on a reasonably easy specification than to supply a small number on a stiff specification at a higher price.

Where the forest goes

It has been calculated[1] (in America, but this applies more or less equally to India also) that only about a third of the wood in a well-managed forest becomes finally usable timber.

The diagram below illustrates this.

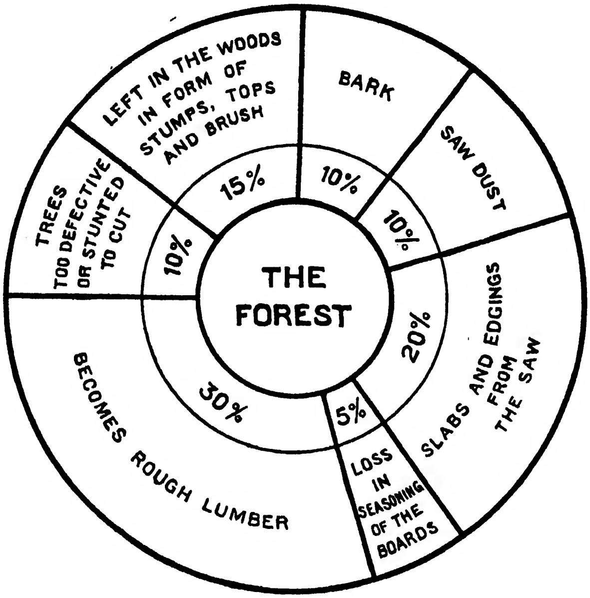


DIAGRAM 5. Wastage in conversion

Machine sawing

Machine sawing, under favourable conditions, should usually be a more profitable undertaking than hand-sawing. The essential factors for the successful establishment of machine sawing are that:—

(1) There is a sufficient supply of timber to keep the machines continuously at work.

(2) The timber can be sold more profitably after conversion than in the round.

(3) The cost of the machine sawing is less than that of local hand-sawing.

If these essentials exist, there is every prospect of machine sawing being successful.

The establishment of a sawmill, however, means the sinking of much capital on machinery, etc., and anyone contemplating such an enterprise would be well advised to study local conditions carefully before plunging into such a venture

[1] Taken from *Forest Facts for Schools*, by C. L. Pack and Tom Gill, 1931 edition, published by The Macmillan Company, New York.

—which time and again in India has resulted in disaster. The communications to and from the mill are specially important features, as without means of bringing logs cheaply to the saws, and taking converted material away, a sawmill stands a poor chance of being successful. The material to be sawn is also a factor not to be overlooked, as the percentage of waste plays an important part in such a venture. Finally, labour conditions must be studied, and especially the available supply of hand-sawyers, as it would obviously be unwise to start machine sawing where a plentiful supply of hand-sawyers is available at cheaper rates than machine sawing costs. In the majority of forest districts of India, hand sawing is preferred to machine sawing, but there are, on the other hand, several areas where machine sawing has proved a profitable undertaking. Of late years, small semi-portable sawing outfits have been introduced for the conversion of logs in the forest, and where properly supervised by an experienced hand, these have proved successful. The difference between profit and loss in mills of this kind is, however, so small that the greatest care should be taken in appraising the local conditions, and above all in having a practical sawmill man of experience in charge of the operations. Speaking in general terms, there are two distinct types of sawmills, namely those mills which are situated in the forest itself, and those which are at some central place away from the forest. The former are usually small mills with perhaps one or two machine saws and their auxiliaries, while the latter may be very large concerns handling many thousands of tons of logs per annum, and equipped with all the different types of machines used for the conversion of logs into planks, scantlings, battens, and other forms of sawn material required by the market.

Small forest sawmills are used in Bengal where they are worked successfully by the Forest Department, and in the Central Indian States where they are run by private enterprise. Large sawmills are more common in Burma, on the west coast of Madras and at the large railway centres in India, where immense quantities of converted material are required by railway carriage and wagon shops.

It is not the intention here to discuss the details of machine sawing and sawmills, as this subject is dealt with in full in Chapter X, and the student interested in this subject cannot do better than to absorb all the information given therein.

Markets

The demands of the local population have always the first call on local forest production. Very often, however, this demand is for inferior grades of produce, while the better classes of timber are exported to the larger markets or sold direct to the Indian railways and other large buyers, and, in the case of teak and

a few other timbers, exported to European and other countries. Established markets and their requirements must be given the closest attention, and where markets do not exist for the whole outturn, constant endeavours must be made to find or create a market. This is often a matter of considerable difficulty, as timber users are usually very conservative, but if full particulars as to the qualities of the timbers to be sold are made available and presented in attractive form, new markets can often be procured.

Grading

The grading of timber for sale is a very important matter which is receiving more and more attention in India. Every depot has usually its own local grades and customs. Once a classification has been adopted all parcels must scrupulously conform. Nothing is worse for trade than any suspicion of sharp practice.

In general, grading rules should deal with the following:—

(1) The regulation of standard sizes in accordance with market demand and manufacturing practice.
(2) The definition of grades indicating the defects permissible in each.
(3) The permissible allowances for shrinkage and manufacturing variation.
(4) The definition of technical terms used and an explanation of defects.

The essentials for grading are:—

(1) Definition of the defects which occur in the woods to be graded and a knowledge of their effects on the timber. On this the material can be sorted into classes according to quality and size.

(2) Apart from the strength value of any defect, it will have a value which depends on the use to which the wood will be put. For example, it might be no defect to have a stain on wood to be painted, whereas for wood to be used in natural finish it would be a serious defect. This amounts to the fact that basic rules drawn up on quality, i.e. freedom from defects, need modification in application to particular uses.

(3) Timbers vary greatly in properties, but there is general similarity in the defects which are found in woods. On this account it is possible to draw up general basic quality classes applicable to all timber trees.

III

TRANSPORT

BY LAND

FOREST ROADS; dragging by means of animals—extraction by means of carts and pairs of wheels—extraction by rolling—the extraction of sawn timber and firewood. TIMBER SLIDES; dry slides—wet slides. FOREST RAILWAYS AND TRAMWAYS. OVERHEAD TRANSPORT; gravity ropeways—power ropeways. SKIDDING. CHOICE OF METHOD.

BY WATER

FLOATING; logs—sawn timber. RAFTING; booms—rafts.

BY LAND

FOREST ROADS

Under this heading are included all types of roads, whether permanent or temporary, main roads or small extraction paths.

Permanent roads are those laid out as part of the general scheme of management. A well-devised road scheme should invariably be projected with due consideration for future extraction requirements. This is particularly important in the plains. In the hills, the ordinary roads and inspection paths are not of much use for timber extraction. The principal roads in a system should be in, or lead to, direct communication with timber markets, rail-heads, or waterways, and every subsidiary road or path should be made to serve as large an area of forest as possible.

Temporary roads intended only for timber extraction are constructed wherever necessary to supplement the permanent roads. In the plains, they may be unnecessary when timber is being extracted, provided a good system of permanent roads and rides exists, but where logs have to be dragged, temporary roads will be required, as this method of extraction is very damaging to permanent forest roads, which should not be used for this purpose more than is absolutely necessary.

In the hills, log-rolling roads and sleeper-paths cannot often be combined with ordinary roads, and must therefore form part of a special extraction project and are generally of a temporary nature. Roads and paths used for transport

of timber differ according to the means employed to extract the timber and, to some extent, as to whether the produce is in the form of logs or converted material. Various types of extraction are described below.

Dragging by means of animals

The draught animals used in India for extraction are elephants, buffaloes and bullocks, the first two being the strongest. Ordinary forest roads should not be used, but rough earth roads should be prepared by felling trees, removing stumps and other obstructions, or by making the alignment pass round large obstructions. Slopes against the load should be avoided whenever possible, particularly when large logs are to be extracted, but otherwise the alignment should take the shortest course to the depot or floating stream. In soft ground, cordway roads are made by half sinking suitably sized round billets across the road at intervals of a few feet. In other cases, dragging may be facilitated by placing round billets in front of the logs to act as rollers; these are taken up from behind and again placed in front as the log proceeds. A log can be moved along very rapidly by this means if the gang working the rollers are efficient at their work.

Chains are generally used for dragging, though forest fibre ropes are not infrequently used. They are attached to the log in a variety of ways. Large ringbolts with a very coarse thread are sometimes screwed into holes augered into the log about a foot from the end. Another common method is to pass the dragging chain round the end of the log, driving in a short iron bolt just in front of the chain to stop it slipping. The method used most commonly, however, is to cut drag-holes near the end of the log and to pass the chain through it. These drag-holes can again be used subsequently in rafting. It is important to see that the attachment is made on that side of the log which will allow the best dragging surface to be in contact with the ground. The front end of the log (as mentioned above—pp. 59-60) is slightly rounded off to prevent it from ploughing into the ground, but this rounding of the end must not be excessive or timber will be wasted. In some districts in India and to a small extent in Burma, short wooden sleds are sometimes used to raise the leading end of the log, and this avoids snouting and helps the log to slide well. Where logs have to be dragged up steep slopes, a system of pulley-blocks can be used.

Where animals are employed, dragging has to stop during the hot weather, and work should be so organized that extraction is complete before the hot weather begins. Dragging is not really a very efficient method of extraction but is often the only one possible. It is moreover very destructive to road surfaces and should not be permitted on roads if other forms of transport are possible.

Extraction by means of carts and pairs of wheels

Wherever roads or cart-tracks can be used, carts should be used in preference to dragging. Approximately twice the load can be carried on a cart that can be moved by dragging with the same animal power, and the distance will be covered in a quicker time. For very short distances, however, it may be cheaper to drag than to cart the timber owing to the time taken in loading. The ordinary country cart is quite suitable for carrying small logs. In Burma, timber carts of various types are used. They differ mainly in the size of their wheels. In general, they consist merely of a pair of wheels with a strong wooden block, slightly concave at the centre, fixed over the axle, and a pair of shafts. The log is supported on the wooden block over the axle. In Europe and other countries, logs are transported by slinging them in chains below the axles of one or more pairs of large wheels. In the former case, the small end of the log trails on the ground behind. In the latter case, the heavy end of the log rests over the axle of the front pair of wheels, and the small end is suspended under that of the rear pair. Logs can be loaded on carts in various ways. In north-west India, the cart is laid on one side either with or without taking the wheel off; the log is roped to the cart, which is then levered to the upright position with the log attached. In Burma, logs are often rested on a large cross-log and the carts are backed under them. The logs are then levered forward until their balance is transferred from the cross-log to the axle of the cart. The logs are only fastened to the cart by one chain, balance being maintained by the driver who sits on the log. Where large numbers of logs have to be loaded continuously, as at a timber depot, loading is usually done by means of a rough wooden gantry and a block and tackle.

Extraction by rolling

In the plains, rolling roads may be made on flat ground or gentle slopes by clearing away all obstructions along the desired alignment. Logs can be rolled by elephants, or by men using stout wooden levers, or preferably some such log-rolling tool as the kant-hook or American peavy. Rolling roads are extensively used in the Himalayas, where they are employed for transporting logs across steep slopes. These roads are generally expensive to construct, and a logging scheme entailing much road construction should not be undertaken without carefully counting the cost beforehand. Hill logging-roads are almost always combined with some other system, such as chutes or slides, in a general scheme of extraction. The roads act as collectors or as the means of linking up two suitable sites for earth chutes. In the alignment of these roads, curves should be avoided as much as possible. The maximum gradient should be 10° and the

PLATE IV. Rolling road for logs

Facing p. 76.

PLATE V. Large raft of logs in the Andamans

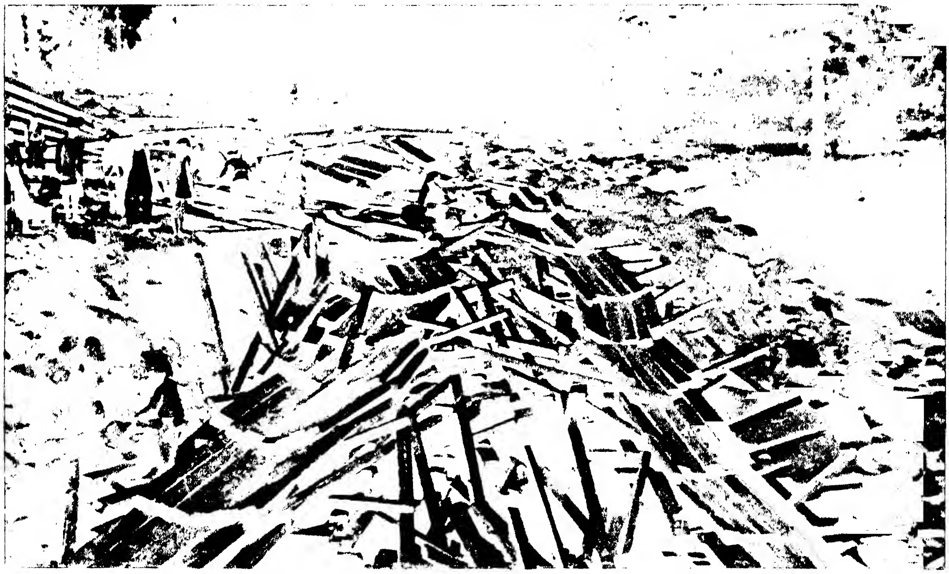


PLATE VI. Sleeper slide in the Punjab

Facing p. 77.

mean gradient about 3°. Abrupt changes in gradient are undesirable. These roads are constructed in the same way as ordinary roads, and while it is important that the outer edge should be well-supported, no money should be wasted on unnecessary finish. The width depends on the length of the largest logs. Rails to facilitate rolling are sometimes made by laying two parallel rows of poles half sunk in the ground, but this is not advisable on steep slopes, as logs are apt to roll too quickly and get out of control. Rolling work is not unattended with danger and must be carefully controlled. Only one log should be moved at a time in each sector. The first log of a batch should be rolled for a short distance only, and then wedged secure with stones. The next log should then be rolled up to it, and so on, until the whole batch has been moved up. Wooden levers or peavies are the only tools used for rolling logs. Rolling is usually done on contract, at so much per cubic foot on delivery at the launching depot. The construction of roads, chutes, and check-walls is always done departmentally.

The extraction of sawn timber and firewood

(1) In the plains, country carts are used extensively for the carriage of sawn timber and firewood. This method of transport is cheap, and very suitable for a country like India where carts are understood by all.

(2) Pack animals, such as camels, mules, and donkeys, afford a cheap method of transport where carts cannot be used or are not available. Camels are used in Northern India for the carriage of sleepers. Mules, ponies, and donkeys often carry firewood, but their loads are considerably less than those carried in carts.

(3) In the Himalayas, scantlings and sleepers are usually carried from the forest to launching or other depots on men's backs. Rough carriage paths costing only a few rupees per mile are constructed for this purpose. These paths are often only 12″–18″ wide, except where they have to cross precipitous ground, when they have to be carefully constructed and may be rather costly. Cooly carriage is usually done on contract, the rates paid for delivery at the launching depot depending on the size of the timber and the length of the carriage path. This method is replaced wherever possible by overhead transport, as carriage coolies demand high wages and the supply is often uncertain.

(4) Motor transport is sometimes used for the extraction of converted material, but this form of transport is usually expensive and only justifiable under certain conditions such as when good motor roads exist along the line of transport. It is not a means of extraction employed much in India, but there are cases in existence where the transport of timber by motor lorries has proved to be the best means of conveying timber from the forest to the sawmill and from the sawmill to the markets. One timber firm has reported that the use of

motor transport for the conveyance of timber turned a loss into a profit, and has proved cheaper than any other form of transport.

Timber Slides

Log slides were at one time used in the Himalayas, but they require a very large outturn to justify or even make possible their construction. The only form of log slide used is the earth slide or chute, which merely consists of a trough scooped out down the hillside. Small stream beds, provided they are not too steep or rocky, can serve the same purpose, and are frequently used as sections of rolling roads. Log sliding in earth chutes has to be done carefully, or logs may be badly damaged by smashing into rocks, or heaps of logs may be damaged by others crashing into them from above. Logs must be kept under control when sliding or rolling is done, and where the gradient makes this impossible, it is necessary to construct stout check-walls at intervals down the slide or chute. These check-walls can be made by firmly sinking a row of logs vertically in the ground to form a palisade. The upper side of the wall is usually banked up with earth and branchwood to save the descending logs from being damaged. Check-walls are also constructed where a change of direction is necessary.

Slides used for the transport of *sawn* timber are divided into two classes, known as dry slides and wet slides :—

Dry slides

In this case, the timber moves down by virtue of its own weight. Dry slides have many disadvantages and are not much used in India except in short lengths, such as where it is necessary to discharge scantlings into a river from a depot on a steep bank above it. The chief disadvantages of dry slides are :—

(1) The timber suffers considerably more wear and tear than in wet slides.

(2) As the timber travels by its own weight there is little latitude for varying the gradient, and the timber is liable to travel too fast or to stop altogether.

(3) A gradient suitable for dry weather allows the timber to travel too fast when the slide is wet with rain.

(4) It is difficult to run a slide divided into sections, because the timber has to be stopped in hollows dug in the earth at the foot of each section and must be cleared down the succeeding section before another scantling arrives. This is easily accomplished in pools in wet sliding.

(5) No reliance can be placed on brakes or on grit thrown into the slide as measures to check the speed of sliding timber. On steep gradients momentum varies considerably with the same class of timber.

The only advantage of dry slides is that they do not require water-tight joints and can be used where no water is available. Their use is, however, not recommended, except where only a short steep length is required, and conditions are favourable for their use.

Dry slides are sometimes used for the extraction of *firewood*. They can be constructed as a trough formed of poles resting side by side on wooden blocks, each section overlapping the one below it, or they can be constructed of planks set on wooden blocks.

Wet slides

Wet slides, as a means of extracting railway sleepers and other sawn material, have been in use in the north-western Himalayas for a long time, and although they have to some extent been supplanted by portable wire ropeways, they are still used as one of the chief methods of extraction in some forests. In these slides, water is used as a motive power in addition to gravity. It is not proposed to trespass into the realm of engineering, but a brief description of a wet slide is desirable here so that the management and organization of slide work to be described later can be readily understood.

Briefly, wet slides consist of a rectangular trough constructed from convenient classes of timber, mostly sleeper sizes, cut for export in the forest. The pieces used in the slide are exported when the slide is no longer required. All joints must be made as water-tight as possible. This is effected partly by trimming the wood and partly by stuffing all cracks with moss or grass when the slide is completed.

The trough thus consists of a number of sections, of the length of the timbers used, which are firmly fixed at each joint into blocks or 'cradles' specially notched to receive them. An additional cradle should be fitted at the centre of each section if increased stability is required. The success of this method of extraction depends on the maintenance of a sufficient and continuous flow of water down the slide. The greater the depth of water the better, for on very low gradients deeper water increases the speed of the scantlings while on the steeper slopes it acts as a very efficient brake as the timber tends to travel faster than the water. It is quite impossible to avoid leakage altogether, and as the length of slide increases the flow of water diminishes. There is, therefore, a limit to the length of slide which it is possible to run continuously without augmenting the water supply. The water supply can, however, be replenished by means of short

lengths of trough which carry water to the slide from the original supply or from some side stream. The best method, however, is to divide the slide, if it is a long one, into a number of control sections. The length of these will naturally vary considerably, but it is best that they should not be much over 2,000 feet in length. Each control section receives a fresh supply of water, but in addition to this other advantages accrue, (1) control of sliding operations is greatly facilitated if the slide consists of a number of sections instead of one continuous length, (2) should one section break down, the others can still be worked to some extent. Under these circumstances the whole layout consists of a head pool at the launching depot formed by damming the stream. The timber is launched into the pool and directed down the first section. At the end of this section another pool is made into which the scantlings are discharged. This pool acts as the head pool for the supply of water for the second section and for directing the scantlings down the second section. This procedure is followed for all other sections, the last section finally discharging the scantlings into the floating stream.

Wet slides are expensive and very vulnerable to damage from floods, landslips, etc., and breakdowns have always to be anticipated. The construction of wet slides frequently demands considerable engineering skill, and no costly scheme should be embarked on before examining all the alternatives. Where the alignment has to follow a difficult valley, information as to the fluctuations and habits of the available water supply must be investigated. A well thought out programme which takes into consideration the time taken to build the slide, the completion of sawing and delivery of the timber at the head of the slide, the earliest date on which it is safe or possible to start sliding operations, and the latest date by which all timber must be delivered at the main floating stream, is an item of the utmost importance. Failure to take all these matters into consideration may result in disaster to the whole scheme, however skilfully the slide may have been constructed.

Wet slide management can only be perfected by experience, but this is often obtained at a high cost, and even though some of the following points may seem trivial at first sight, it will be found in practice that careful attention to them will contribute considerably to the success of any wet slide scheme.

Alignment.—(1) It is generally not possible to operate slides during the rains owing to fluctuation in the level of streams and to the difficulty of dam-construction at that time.

(2) It is always necessary to align the slide well above high flood level.

(3) Wet slides can work satisfactorily at as low a gradient as $\frac{1}{2}°$, provided that construction exactly follows the alignment, that the joints are made as water-tight as possible and that a good head of water is maintained. Above 25°, scantlings are liable to jump out of the slide unless the trough is covered in.

(4) Unstable ground should be avoided at all cost.

(5) Sharp curves should be avoided, particularly on steep gradients.

(6) Before detailed alignment is undertaken a careful survey must be made of the country to be covered, and all obligatory points and suitable sites for pools carefully examined.

Construction.—(1) Construction should not be started until the alignment has been finally settled.

(2) As much material as possible should be collected at convenient places on the alignment before construction begins.

(3) Work on the more difficult portions of the alignment should not be left to the last; labour gangs should be carefully organized for the various jobs so that there will never be any delay and work will be properly proportioned.

(4) It pays to employ the most experienced slide *mistris* in spite of the high wages they demand.

(5) The floor of the slide should be of uniform width throughout and not widened at curves as is often advised; jams are far more likely to occur at points where increased width allows two scantlings of different sizes to draw abreast. To allow for the passage of long scantlings round curves, the radius of the curve must be increased. The narrower the trough the better. Usually it should be not more than 6″ wider than the widest piece of timber to be floated down.

(6) On steep gradients and at sharp curves, the slide must be strengthened by the use of dog-spikes and by increasing the number of cradles.

(7) If the timber being extracted includes more than one species, scantlings of the least valuable species should be used for temporary slide construction, but if the slide is to operate for several years, the most durable species should be used.

(8) Under average conditions a slide *mistri*, assisted by an adequate gang of say 10 coolies, can construct about 500 feet of slide in a month.

Slide working.—(1) The slide should be gone over for repairs every morning before work starts. It is also a good plan to stop work for half an hour at midday for an overhaul. A defect seen and corrected in time may save considerable delay later.

(2) It does not pay to launch scantlings down a slide in quick succession, as jams will result. About four scantlings per minute gives the smoothest working and pays in the end.

(3) If possible, float timber down in batches of the same size-class and species. Heavy scantlings travel faster than light ones, and where odd sizes and lengths are sent down, jams are far more likely to occur. Smooth working can only be obtained when scantlings do not overtake one another. Steady continuous working is what should be aimed at.

(4) Adequate arrangements must be made to ensure that there is as little delay as possible in the event of a breakdown occurring.

Cost.—The cost of constructing a wet slide should average out at from As.10 to As.15 per running foot. Construction on inclined rock is three times, and on high trestling twice, as expensive as on flat ground or on low trestling. Construction, and sometimes maintenance, is expensive, and the use of long wet slides can only be justified by a large outturn. The method does not deliver the timber in as good condition as either carriage by coolies or ropeways, while the timber used in the slide itself depreciates in value. It is a cheaper method of transport than coolie carriage, but more expensive than ropeways or 'telescopic' floating, though the last-named method is liable to cause more damage to scantlings. Wet slides are used, other things being favourable, when the topography is unsuitable for ropeways, when the conditions of the stream are too unfavourable for 'telescopic' floating, and when the length of the lead places the cost of and delay involved in coolie carriage out of consideration. Once the slide has been constructed, the delivery of the scantlings at the main floating streams is quicker than by any other method.

Forest Railways and Tramways

The use of light railways and tramways in the forests for timber extraction and transport is very common both in Europe and America, and has been developed to a certain extent in India. The initial cost of a railway with its rolling stock is very high, and this cost must be distributed over a large quantity of timber to make it pay. Since the selection system with its scattered fellings is still practised more extensively than any other system in India, there is not at present any likelihood of railways or tramways coming to the fore in any great degree. Further, where a good system of waterways exists, water transport will probably always be preferred in spite of its disadvantages, such as higher transit losses, and delay in delivery of timber. In many forest localities the cost of railway construction is prohibitive, on account of the numerous bridges and deep cuttings required.

Forest railways differ from tramways in that the motive power is supplied by an engine, either steam or internal combustion, while on tramways the trucks are drawn either by men or animals, usually the latter, or are propelled by their own momentum. Another difference lies in the nature of the rails. In railways, the lines are heavy and are laid on wooden sleepers in much the same way as for ordinary railways. Forest tramways, on the other hand, have light rails which are permanently united with narrow metal sleepers, and are of a much more portable nature. Tramways can be used in far more hilly country than railways,

as they do not require such an expensive track, but they are only used to a limited extent in India. Their carrying capacity is low compared with the cost of purchase and construction. Forest tramways have been used in Burma, Madras, Assam, and the United Provinces, with success, and if conditions are favourable and sufficient material for extraction is available they are a good form of transport.

Forest railways are in more common use. In the Punjab an excellent system has been working for some time in the Changa Manga plantations for the extraction of firewood. In the United Provinces there are two systems. In Burma, light railways are used for the extraction of unfloatable hardwoods. The gauge is usually 2′. Metre Gauge railways can also be used, and they are more economical than the 2′ gauge, as their carrying capacity is far greater while maintenance charges are not much higher. The initial cost of a metre gauge line is slightly higher, and it is best used where a large amount of timber can be reached without having to move the rails. Temporary or 'spur' tracks are often laid in conjunction with a permanent export track, in order to connect the latter with the felling areas as they change from year to year.

Two conditions must be satisfied before a forest railway or tramway can profitably be laid down:—

(1) There must be a constant and sufficient demand for the produce.

(2) There must be a sufficiently large quantity of produce available for export near the line of the tramway or its branches.

As an example, where the whole of the produce of a compact block of forest can be exported along one line to reach the market, it may pay to construct a railway. Again, where a plantation is being worked perpetually for fuel, a railway along the common line of export with temporary branches to the annual coupes might prove to be the most economical method of extraction.

Overhead Transport

Overhead transport means the extraction of forest produce by means of aerial wire-ropeways. Ropeways can be divided into two main classes:—

(1) Gravity ropeways.

(2) Power ropeways.

In gravity ropeways the motive power is supplied by the weight of the material which is transported down the cables. This type of ropeway can, therefore, only be used where the nature of the ground is such that the cables can be so fixed that a sufficient slope is given to allow the load to descend by itself to the bottom. With power ropeways, the load is moved by means of an engine, so they can be operated over flat ground or even to move loads uphill.

Gravity ropeways

Gravity ropeways are extensively used in Europe, and of late years their use has increased in India; but they are not likely to be very widely used, partly because the system of sale of coupes to contractors is widespread, and these men, even if they had the means of purchasing ropeways, could never be certain of continuous employment in the same locality. In addition, the extraction of logs by ropeways in the Himalayas is scarcely practicable, as it is not possible to handle the heavy cables which would be necessary to transport large logs. Again, the systems of management usually in force in the hills would necessitate the frequent shifting of the ropeway from one locality to another. These conditions, generally, preclude the employment of heavy tackle. It is natural, therefore, that extension in the use of ropeways has been almost entirely in the direction of lightness and portability, and has culminated in the perfection of a light and portable system suitable for sleeper and scantling extraction. This system is described later on.

In its most elementary form, a gravity ropeway consists of a wire cable stretched between two points, at both of which it is anchored. The inclination of the cable should be sufficient to allow the load to slide down with sufficient force to reach the bottom. The load is usually attached to and runs on the cable, either by means of a wooden saddle or a pulley-wheel, the correct amount of sag being given to the rope to allow the load to arrive at the bottom station without undue speed. Preferably the load should stop of itself as it reaches the lower station. If the method of attachment is by pulley-wheel the system cannot be used on very steep gradients, as there is very little braking effect from friction and the timber would increase in speed rather than lose it. There is always danger of the load striking the lower station and causing damage, and this system is therefore only suitable for the extraction of light material such as firewood.

It is the more common practice to use a moving control rope in conjunction with one or more fixed ropes. The loads are attached to the control rope, and their speed of descent can thereby be regulated. This system can therefore be used on much steeper gradients. There are various types of ropeways. In some the control rope is endless, passing round sheaves or drums at the upper and lower stations. In another type there are two control ropes and two fixed ropes, the two control ropes being fixed to a drum at the top station in such a way that one unwinds letting down the descending load while the other winds up drawing up the empty carriers. Another variation is a single fixed rope system with a single open control rope which passes round a drum at the top station. One end of the rope is attached to the load at the top when the other is at the bottom; as the load descends it draws up the other end of the control rope which is attached to the empty carriers. At the point where the two meet halfway there is a special device fixed on a standard whereby the two can pass one another.

The system which has proved most useful for sleeper and scantling extraction in the north-western Himalayas is known as the Donald portable gravity ropeway. This system consists of three fixed ropes set parallel to one another at about two-feet intervals. They are anchored at the top and bottom stations, and are stretched to the required tension by rough windlasses at the bottom station. The control rope, which is rather lighter and more flexible than the fixed ropes, runs round two cast-iron grooved sheaves, the two ends being joined by a long splice. The load is suspended crosswise below the three fixed ropes by three carriers, which consist of pulleys and an attachment to which wire slings fastened round the load can be hooked. Another wire sling round the centre of the load is fastened to an 'eye' let into the control rope. When the load descends it pulls up the empty carriers which hang from another 'eye' at the lower end of the control-rope. As soon as a load reaches the bottom station the scantlings are removed, and the empty carriers are attached to the control rope, during which time another load is being prepared at the top station. A simple but effective lever-operated band-brake is operated on the sheave at the bottom station. The great advantage of this system is its portability and simplicity. It has not been found difficult to train local labour in its use; no special engineering skill is required, and spans can easily be erected, operated, and dismantled by the local staff. The Donald ropeway is worthy of wider use. The following features are useful to know:—

(1) The ropes can be coiled up into linked bundles and easily carried by a string of coolies.

(2) The sheaves are easily portable.

(3) Since a brake is used, the ropeway can be operated at very steep inclinations, 45° is the steepest yet used; 17° is about the lowest practicable inclination.

(4) The safe working load is 9 cubic feet of green timber, or about 500 lb., though the life of the ropes would be prolonged if lighter loads were carried.

(5) Spans over 4,000 feet are difficult to erect and operate. The longest span used in India has been 4,700 feet. Quite short spans of only a few hundred feet are often used to carry timber across ravines, and the use of these ropeways has made possible the working of many forests which had previously been looked upon as inaccessible from the extraction point of view. An extraction scheme often involves the linking up of a number of suitable station sites by several spans in series.

(6) Roping is now usually done on contract, a flat rate being paid for each scantling. The rates vary from 4 pies to 10 pies per scantling

per span, according to the length of the span. Spans are erected and dismantled departmentally. The costs vary considerably but are in the neighbourhood of Rs.120 for erection and Rs.30 for dismantling.

The life of wire ropes depends entirely on how they are handled and how often they are moved from one site to another. The life can be greatly increased by observing the following instructions:—

(1) When coiling and uncoiling the ropes and when setting up or dismantling the spans, care must be taken to avoid kinks. Some kinks are bound to occur, but they should be carefully taken out before the ropes are again used. A rope quickly frays at places where it loses its round shape.

(2) Care must be taken to see that the two sheaves are in exact alignment, so that the rope will run in the centre of the groove. Wear and tear are greatly increased if this is not done.

(3) The three fixed ropes should have as nearly as possible the same tension.

(4) The two ends of the control rope must be very carefully spliced together.

(5) Scantlings should be so loaded that the weight is equally distributed under the three fixed ropes; this ensures equal wear on all three.

(6) All ropes must be kept well-oiled.

(7) The maximum load permissible must never be exceeded.

(8) Loads should not be allowed to descend too rapidly. Apart from possible danger, a fierce application of the brake often causes the control rope to skid round the sheave and increases the wear.

(9) If ropes are kept well-oiled it is better to leave them up over the winter, as the more ropes are handled the quicker they deteriorate.

(10) It is essential to keep a careful record of all ropes. This record should give the date when a rope was first put into use, the number of times it has been moved, and details of the scantlings carried.

In conclusion it can be said that gravity ropeways are the most efficient means of transporting timber in hilly country. They deliver timber in the least damaged condition, are very cheap and adaptable, and are speedy in delivering timber at the depots.

Power ropeways

These are used extensively for the transport of material in many industries in India, but only a few systems have been installed for the export of forest produce. The erection of these ropeways requires considerable engineering

skill and is really outside the province of forestry. Two power ropeways are working in North India, one at Patriata in the Rawalpindi West Forest Division, where it is used for the transport of fuel for sale in Rawalpindi. The other is in Khanpur Division of the North-West Frontier Province. This ropeway, in addition to transporting timber and fuel, is also used for carrying general military supplies.

The system is the same in both cases, a single endless cable carried on intermediate supports carries the loads and is moved by a large drum turned by steam.

Skidding

'Skidding' is an American term for hauling logs by means of a wire cable and steam power. It is especially useful for dealing with heavy logs. The method has been tried in Burma, Madras and in the Kurseong Forest Division of Bengal, but it is not likely to be used very much in India. To make it a financial success, large and highly concentrated yields are necessary. The outfit consists of an engine with one or more rope drums, mounted on long wooden 'skids' laid as rails, along which the engine can be moved as necessity arises. In *ground skidding* the wire cable is first dragged out by men or animals, and is then attached to the log and hauled in by the engine turning the drum. In *high-lead skidding* the cable runs out over a block attached to a tree at a height of 80′ or over. In this way the nose of the log is kept clear of the ground, and clears obstacles more easily as the cable is wound in. This method is largely employed in British Columbia for the extraction of heavy logs of Douglas fir in clear-felling operations. It is unsuited to Indian conditions.

Overhead skidding is of the nature of aerial transport. A horizontal cable is attached to trees or spars, and along this a special carrier runs which conveys the logs. The hauling cable is attached to a carrier which moves along the fixed rope as the drum winds in the hauling rope.

It is not a method employed in India.

Choice of Method

Before deciding on what method of transport to adopt, or the advisability of changing an existing method, a number of important considerations have to be taken into account, and their relative values balanced one against the other. The more important of these considerations are briefly dealt with below.

Cost

Ordinarily, the cheapest method is the most preferable if it is feasible. If a change of method is contemplated, a careful comparison of the costs of the

existing and proposed methods must be made. Capital expenditure, if any, must be considered, the amount of produce available must be estimated, the working and maintenance and direct charges must be found by spreading the cost over the estimated output. Finally, depreciation and possibly interest charges must be considered.

Loss and damage to the produce

This is very important. A slight saving in the direct cost of transport by introducing a new method may be discounted by increased loss or damage in transport involved by the new method. On the other hand, any method which reduces loss or damage is to be recommended.

The time factor

In general, that method which is most expeditious in delivery of timber at the sale depots is to be preferred. As a rule, any advantage from the seasoning and drying of timber during protracted delivery is more than balanced by a loss from insect damage and decay. In addition many timbers are more easily sawn when green, and early conversion may be advisable.

Labour

Where labour or the supply of draught animals is scarce, the introduction of labour-saving methods may be beneficial, resulting in greatly increased yields. The introduction of mechanical transport also tends to bring down the local cost of carting and labour wages, which reacts to the benefit of employees and forest exploitation generally.

Forest improvement

The beneficial effects of improving and opening out the forests and making them more accessible must also be considered. For example, the introduction of a good road system might possibly be of greater indirect, if not direct, benefit to a forest estate, than a railway system. The introduction of ropeways often results in the possibility of working forests which were hitherto inaccessible.

Markets

Where only local or fluctuating demands exist, ambitious methods of extraction cannot be considered. All mechanical means of transport are expensive, and the capital outlay is large. They can, therefore, only be considered where the outturn and an assured steady market warrant the expense.

Nature of the country

The suitability of the terrain for any proposed method of transport must be carefully considered in all its aspects before deciding on any means of transport. For example, forest railways are no use in very hilly country, and aerial transport is usually unnecessary on level ground.

BY WATER

The transport of timber by water is the oldest method known to history. Over long distances it is the cheapest method, but it tends to be superseded by railways, because railways can frequently be brought right up to the felling areas. Railways are also more expeditious than waterways, and cause less damage and loss in transit. But in spite of this, the use of waterways whether natural or artificial, will always figure largely as a means of transport for timber. In India, water transport of timber includes two different operations, namely floating and rafting. In floating, the pieces of timber are allowed to drift down with the current of their own accord, and are not under the direct control of men. Rafting, on the other hand, implies the fastening together of timber into compact structures called rafts, which are navigated down the waterways and even along sea coasts. Floating is practised in those parts of streams or rivers which are too narrow, shallow, or rocky, or in which the current is too swift for the management of rafts. Where rivers are wide and the current tranquil, rafting is always employed in preference to floating. It follows therefore, that floating is usually most common in the upper reaches of rivers and rafting in the lower reaches.

FLOATING

Both round and sawn timber can be floated provided the timber is sufficiently light. In Burma and elsewhere, log floating is carried on extensively. In the north-western Himalayas, almost the entire yield of timber is exported to the plains by the agency of rivers, the largest output being in the form of sawn sleepers.

The suitability of a stream for floating logs depends on a number of factors. Almost any stream can be used for floating scantlings, but logs are more exacting:—

(1) The stream must be sufficiently wide to allow the unobstructed movement of the timber, that is, there must be ample room for the timber to turn round and round without getting jammed against the banks.

(2) The stream must be reasonably clear of obstructions; or

(3) There must be sufficient water at some season to float the timber clear of obstructions, so as to avoid jams and undue breakage.

In Europe, the work of improving watercourses has received much attention, and elaborate schemes of weir-construction have been carried out, but for many reasons expensive works of this nature are often impracticable in India. In the Himalayas, river improvement usually takes the form of blasting serious rock obstructions, while in Burma the narrow watercourses running through the forests are annually cleared of fallen trees, stumps, and debris, while the floating streams outside the forests are often straightened, widened, and deepened, to facilitate the extraction of logs in large numbers. Backwaters and the mouths of side streams in which timber is liable to collect can be closed by the construction of lateral booms or palisades across their entrances.

In Burma the most common practice in teak extraction is to work logs into the numerous streams running through the forest by means of elephants. These streams are usually dry, except during the rainy season, and logs are left lying in them until the monsoon arrives and a spate comes down with sufficient water to float them. If, as is frequently the case, there is insufficient water to float the logs the whole way, elephants are used to help them along until they reach the main floating streams, in fact, elephants are largely employed in all floating operations in Burma to patrol the banks and push off stranded logs and to break up jams. All logs which fail to get down to the large floating streams or depots during the first year's floating season have to wait till the following year. In the meantime they have all been placed parallel to the banks so that they are ready to start on their downward journey when sufficient water arrives. Sometimes it takes many years for logs to reach the timber depots in Rangoon, and logs with hammer marks ten years old are not uncommon. In some districts, logs are often buried in the silt of the floating streams, and when floods occur teak logs are sometimes carried far and wide over adjacent country. Cases are not uncommon where many thousands of teak logs have been completely buried in areas well away from the floating stream, but the improvement of floating streams has been a special study for many years in Burma, more especially along the plains below the Pegu Yoma mountains, and floating is now conducted on far more scientific lines than was the case some years ago. In Assam, large logs of species too heavy to float by themselves are brought down from the Lushai and Manipur hills by attaching to them bamboo floats, one float on each side. They are then allowed to drift down uncontrolled until the boom is reached. The same practice is seen in Burma and other parts of India, where a valuable species is too heavy to float by itself.

In the Himalayas, both sawn timber and logs are floated, but the number of rivers suitable for log floating is restricted, owing to the unfavourable nature of the head streams on which the majority of the forests are situated. The floating of logs and scantlings in the Himalayas is described below.

Logs

The usual practice is to launch logs on rising water any time before the rains, so that the fullest advantage can be taken of the high water to carry the logs safely over obstructions. Logs and scantlings should not be floated at the same time, as the water requirements of each are different and logs would very seriously damage scantlings in transit. Scantlings are usually launched at the end of the rains. By launching logs at the beginning of the floating season some logs undoubtedly get carried down beyond the limit of river operations as the booms are not kept in position in high water, but comparatively few get past, for at all the catching depots there are swimmers on inflated buffalo skins who are constantly on the watch for drifting logs. The logs drift down by themselves, and little money is spent on working them down. A small 'sweeping' party is usually employed on re-launching stranded logs, and during the winter, logs which have been left high and dry above the normal flood level are rolled nearer the stream and are automatically refloated as the river rises. In this case also, logs often take years to reach the sales depots, but losses in transit are surprisingly low when averaged out over a number of years.

Sawn timber

Floating sawn timber comprises two quite distinct operations:—

(1) Floating in small side nullahs, or 'telescopic' floating.
(2) Floating in the main streams, or 'sweeping'.

Telescopic floating.—This operation involves the extraction of sleepers and scantlings down narrow side-streams, characterized by rocky and tortuous beds, and with a great variation in gradient. During the dry weather the water in these streams may be reduced to a mere trickle, while even during the rains the flow is still often insufficient to float scantlings over the numerous obstructions. Under such conditions, ordinary floating is impossible, at any rate throughout the greater part of the stream, and telescopic floating is resorted to. This operation consists of making the whole stream floatable by constructing, with the scantlings themselves, rough slides or chutes over or round all the obstructions. These slides are locally known as *pathru*. An open framework of scantlings is built between and over the boulders in such a way that a trough of scantlings placed lengthwise, side-by-side, can rest firmly on it. Depending on the length of the obstruction, the chute may consist of any number of sections with their ends over-lapping. If necessary, the stream can be partially dammed at the head of each length of *pathru*, in order to cause a sufficient flow of water. Generally, a pool has to be made at the lower end of each length as well, so that the scantlings may be discharged into deep water and escape end-on damage.

Scantlings may also be passed over quite high waterfalls by constructing a framework, which will carry a *pathru* from the lip of the fall at a gentle slope to a point some way below the fall.

Pathru construction often begins from the launching depots and is extended downstream, scantlings being floated to the head down the part already constructed. The banks of those stretches which do not require *pathru* are lined with scantlings to ensure smooth floating throughout. When all timber has been launched, the *pathru* is progressively broken up from the back and floated to the head, which is being continuously extended downstream. In this way the whole *ghal*, which is the local name for one complete unit of extraction in floating operations, gradually moves down to the main stream, into which it is discharged.

The disadvantages are:—

(1) That in spite of careful supervision and precautions, there is bound to be some end-on damage to the timber.

(2) There is a limit to the steepness of the nullahs in which this system can be employed. This depends on a number of factors which need not be discussed here.

(3) Should there be a sudden spate, the whole *ghal* is at the mercy of the water and rocks, and the timber may be very seriously damaged.

Generally speaking, telescopic floating is best employed in long nullahs of easy to moderate gradient, where coolie carriage and wet slides would be too expensive, and where the slope is insufficient for the employment of ropeways. But Himalayan nullahs are so variable in nature that telescopic floating has sometimes to be combined with wet slides, or ropeways, or even with both.

Sweeping.—In the main floating streams the timber floats down with the current, but a very large number of pieces always become stranded on obstructions such as rocks and sand-banks, or are caught up in backwaters. Gangs of coolies are then formed into a sweeping party, which is employed in re-floating this timber. The main party is composed of small gangs, some of which are posted ahead of the main sweep at points where scantlings habitually get stranded in large numbers. Their duty is to keep scantlings moving and to keep the jams as small as possible. The main party works at the back of the *ghal*, and they sweep all timber left behind and have to leave a clear river behind them. A sweeping party includes a number of men with inflated buffalo skins, whose work is to swim out and re-float all timber which is stranded in places which cannot be reached by the men working along the banks. As the timber begins to arrive at the boom, the speed of the sweeping has to be carefully regulated to avoid forcing so many scantlings on to the boom that it is in danger of

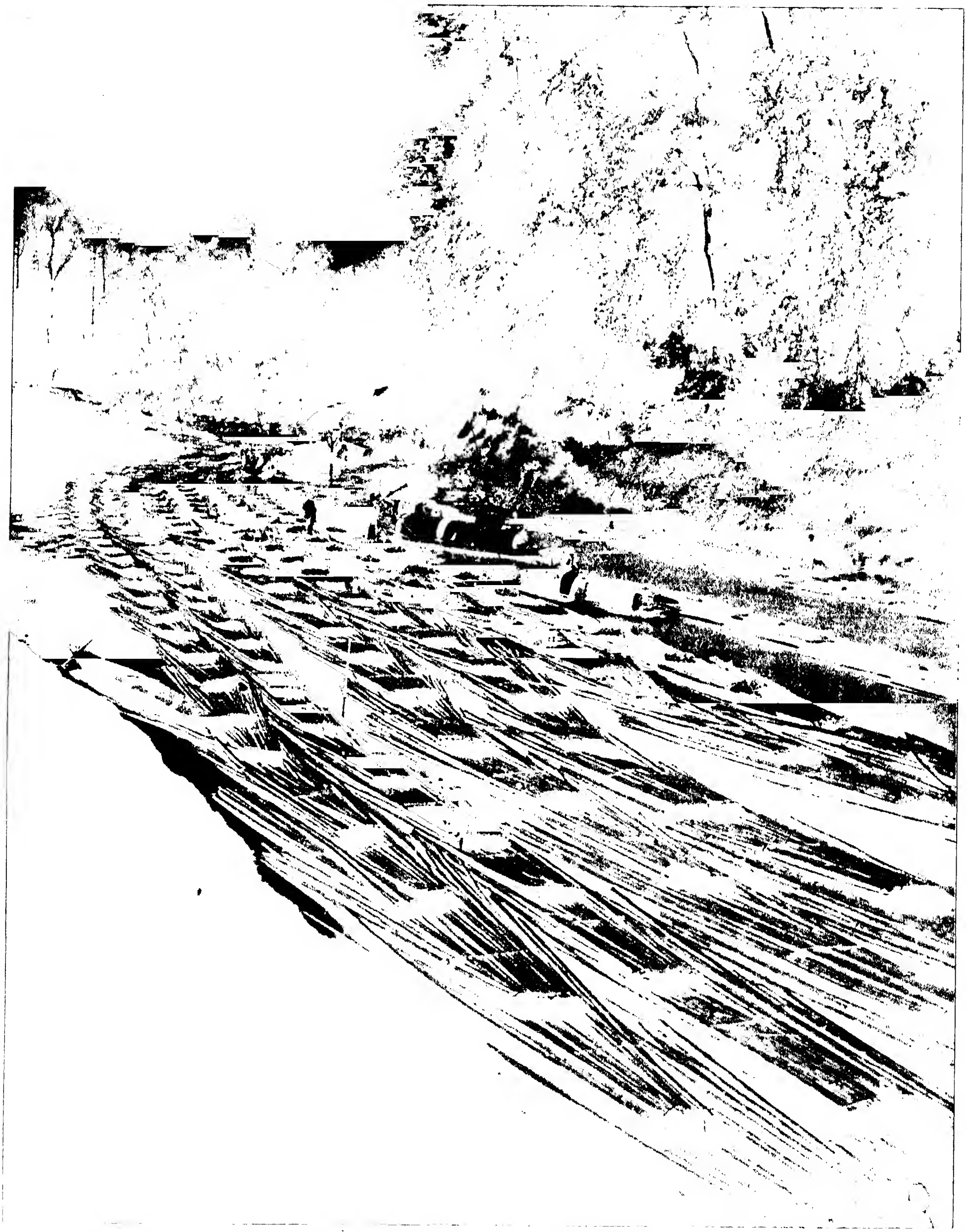


PLATE VII. Bamboo rafts in the Chittagong Hill Tracts, Bengal *Facing p. 93.*

breaking. At the same time, sufficient timber must be delivered daily to keep the catching labour at the booms fully employed.

The correct timing of launching in floating operations is a matter of the utmost importance, and various factors have to be taken into consideration. The sooner timber can be delivered at the sales depots the better are the prices that are likely to be obtained. On the other hand, timber can only be floated when water conditions are fairly safe, or much of it will be carried away and lost. Other considerations, such as the necessity of helping all timber past some cataract or other obstruction before the water falls too low to carry it over safely, may necessitate even more accurate timing. In side nullahs, in particular, where telescopic floating is contemplated, too early launching, before the rains are properly over, may result in disaster, while undue delay may involve the belated arrival at the sales depots of the whole outturn for the year.

Both telescopic floating and sweeping is done by contract; skilled labour from special districts being recruited. Before launching, the timber in all depots is carefully checked in the presence of the contractor, who gives a receipt for the timber in them. Although the contractor is then responsible for all the timber taken over, floating operations are carefully supervised by the forest staff, where departmental extraction is practised. The contractor is paid on the quantity of timber he delivers at the boom, and a clause in the contract binds the contractor to pay for any timber lost in transit, in excess of a certain fixed percentage of the timber handed over to him. This is usually five per cent. The whole operation of floating concludes with an enumeration, during the winter, of all the timber left behind. This is stacked, above high-water level, ready for re-launching the following floating season.

Rafting

As has already been explained, rafting of timber can only be carried on in waters which are free from rapids and serious obstructions, and, in the case of rivers, where the channel is sufficiently wide and the speed of the current moderate. In the large rivers which have their origin in the Himalayas, such conditions do not ordinarily exist until the rivers have debouched into the plains. In Burma and some provinces of India, rafting begins as soon as the rivers are sufficiently large and free of obstructions. Logs, scantlings and bamboos are rafted, and not infrequently other forest produce, such as grass, is brought down the rivers on timber rafts.

Booms

Before rafting can begin, it is often necessary to catch the drifting timber that has been floating of its own accord up to that time. This is usually done by

stretching booms across the river. In Europe, fixed or permanent booms, involving a considerable amount of constructional work, are often used, but in India, owing to the great fluctuations in water-levels and to the size of most of the rivers, only temporary booms are used. They remain in position only while floating is in progress, and are removed before there is any danger of their being broken by rapidly rising water. All temporary booms float on the water and are anchored to the banks at both ends. There are many varieties. In Burma, the usual type consists of logs placed end to end and fastened together with short chains or wire ropes passed through the drag-holes. Where extra strength is required, single logs are replaced by bundles of three, bound together side by side. Another type consists of long canes twisted together to form cables. Logs are fastened to the cable at intervals to make it more buoyant. In parts of Assam, ropes of twisted coir or cane are used. Booms are generally moored so that they lie across the river at a slant. The advantage of this is that timber coming into contact with the boom is automatically directed to some extent towards the bank. Landing of the timber is thereby facilitated, and a greater frontage is obtained, while there is less risk of the boom being broken by any increase in pressure due to rising water or accumulations of timber. In the Punjab, very elaborate booms are built on some rivers for the catching of logs, sleepers and scantlings. These booms are constructed mainly of sleepers which are fastened together in sections, either by bolts or by lashing with wire rope, or by both. They may differ considerably in detail, but the general principle is that the sections are linked together by wire cables to which they are fastened. Each cable stretches from end to end, and is fastened to some strong anchorage on the banks. These booms are anchored permanently at their upper ends only (in position they lie diagonally across the river), and when not in use they lie along the bank or may be dismantled and stored. In order to get a boom into position, a number of guy-ropes are attached at intervals along it. These guy-ropes stretch to the opposite bank of the river, and when hauled in, either by hand or winch, the free end of the boom swings out and across the river, and the whole is held in position by anchoring the guy-ropes. Should it be necessary for any reason to let the boom go, the guy-ropes are loosened, and the boom swings back with the current and lies along the bank. When a boom is in position, a 'gate' should be left between the free end and the bank to allow rafts to proceed down-stream.

With regard to the choice of site for a boom, where conditions are similar to those prevailing in Burma, the best site is where the channel is narrow and the banks sufficiently high to prevent logs escaping round the end of the boom during a flood. Where the current is swift, it may be advisable to locate the boom just below a bend, as then the logs may lose some of their velocity before reaching

the boom. It is not uncommon in Burma to see several thousand teak logs coming down a river on a heavy spate, and one has to be prepared for all emergencies.

In the Punjab, the following points are given special consideration in selecting sites for booms:—

(1) The current of the stream must be slow.
(2) There must be shallow water available for tying up the rafts.
(3) There must be sufficient land available on the bank for stacking timber at times of flood.
(4) It is a great advantage if the site is so selected that the current tends to drift scantlings to the side where the rafts are to be made up.

In general, booms should present as large a frontage as possible, with due regard to cost, and they should lie sufficiently deep in the water to prevent timber being carried underneath them.

Rafts

In Burma, the rafting of teak logs is carried out on a large scale, and the construction and navigation of the rafts requires considerable skill. Briefly, the most common type of raft consists of a number of sections which are fastened head to tail with canes, chains or ropes. Each section consists of 16–20 logs, side by side, with the length in the direction of the stream. The logs are fastened together by means of canes or chains passed through the drag-holes. In each section logs are as nearly as possible of the same length, the largest logs being placed in the leading sections. The whole raft is strengthened and protected by single long logs fastened along the sides of the raft, breaking the joints of the sections. Rafts are managed by crews of four or five men who live in small bamboo or grass huts built on the raft. Guiding is done by means of long oars. Non-floatable timbers are sometimes rafted by means of floats made of bundles of bamboos or of some light timber such as *Tetrameles nudiflora* or *Bombax malabaricum*, and it is not uncommon to find some non-floatable logs attached to large rafts of teak or even tied on top of the rafts. Occasionally, logs of some heavy but valuable species are rafted by means of boats to which they are fastened, but this practice has its limitations.

All teak logs rafted in Burma have been standing as girdled trees for two years. Green teak will not float, but after a teak tree has been standing for two years as a dead tree, the timber is floatable. If it were not for this significant fact, the extraction of teak in many parts of Burma would be well-nigh impossible or at the best very expensive. A very careful check is kept on all teak rafts, and all the logs in a raft are measured individually at several points before the rafts are finally taken over at the sale depots.

In the Punjab, log rafts are very similar to the teak rafts described above. One difference is that where the current is swift a log is trailed behind the raft on a rope to act as a brake. Large logs of over 8′ girth are usually taken down in rafts, separately from the smaller-sized logs, in September, when there is more water in the rivers. The rafts themselves are made in the following manner.

All timber arriving at the boom is caught by men swimming on inflated buffalo and goat skins, and is brought to shallow water, where it is made up into rafts. Rafts vary in type on different rivers. On the Sutlej and Jumna rivers, sleepers are placed two deep in rows, the length of the sleepers being at right angles to the direction of the river. Across these, two double rows of sleepers are then placed lengthwise. The pairs of sleepers in the rows are bound together, and also to the sleepers placed lengthwise across them, by ropes made of grass. These rafts are taken down by two men who use long poles for guiding the raft and fending it off the banks. For purposes of check and control of the rafts while in transit, intermediate check depots are established between the booms and the sales depots. The men in charge of the rafts are given *chalans* showing the details of the scantlings in their rafts. These *chalans* are checked with the rafts at each intermediate depot. The work at the boom and rafting, as well as the salving of timber stranded below the boom, is always done on contract.

IV

STORAGE

General. LAND DEPOTS; transit depots—sales depots. MANAGEMENT OF DEPOTS; lay-out—stacking—classification, measurement, booking—stock-taking—protection—clearance.

General

Forest depots are, speaking generally, places where timber is stored. Depots may be broadly classified into transit depots and sales depots. Transit depots are those in which timber has to be temporarily stored, for some reason or other, while still on the way to its final destination. Sales depots are those in which timber is stored pending final disposal by sale, and in which the sales take place. Depots may be further classified under land depots and water depots, both of which may be either transit or sales depots. A land depot implies a site used for storing wood transported by land. A water depot, on the other hand, is used for the storage of wood transported by water.

The large water depots, or log ponds as they are called, seen in Rangoon and other places for the storage of teak logs, are of a special nature and need not be considered at the present juncture, as they are not forest depots in the ordinary sense.

LAND DEPOTS

Land depots will be described under transit depots and sales depots separately.

Transit depots

Transit depots are used for the collection, checking and examination of land-borne timber, and for the catching, collecting, examining, and rafting of river-borne timber. On main export lines these depots may have permanent sites; otherwise the sites have to be freshly selected as the felling areas change. Where the disposal of produce is by the royalty system, depots have to be established for the purpose of counting, measuring, and checking material as it is removed by the contractor. In such cases all that is necessary is that the timber should be stacked in an orderly way, so that it can be readily checked, and that all produce from the forests should be removed only by those routes which pass

the depots. In order to accomplish this it is often necessary to establish more than one 'check depot' in each felling area. It is impracticable to check timber in the forest, and in addition, for silvicultural and other reasons, the sooner the timber is cleared from a felling area the better.

Where timber is extracted departmentally, strict control is maintained throughout the whole line of transportation, from the stump to the sales depot, by means of a careful system of timber accountancy, all arrivals and disposals of timber being entered in the prescribed forms, whatever the method of transport or the nature of the depot may be. Sometimes transit depots may be required only for the very temporary storage of wood, but even so, there are a number of important conditions which must be satisfied. In the first place it must be remembered that timber is seasoning the whole time it is being transported. It should not, therefore, be stacked in the sun as this is bound to start surface drying and cracking. If stacking in the open is unavoidable, the tops of stacks should be covered with a layer of grass or earth about 4" deep, and the stacks should be placed as close together as possible so as to give side-protection to each other. Secondly, all timber should be sorted and stacked by species and sizes, so that checking is facilitated. Stacks should be numbered serially, and the number of pieces and the quantity of material in each stack should be entered in the depot list and written on the stack with paint or coal-tar. Thirdly, where a large depot borders a public road, a notice prohibiting smoking should be posted and a chowkidar maintained. In some localities, a chowkidar may be necessary under any circumstances. In the hills, launching depots on the banks of floating streams must be located well above the highest flood level, the site must be on stable ground and safe from falling rocks and stones. Other things being equal, it should be so situated that the timber can be speedily and safely launched in the floating season. Where transport to and from a depot is by land, sufficient space must be allowed for the free movement of carts or other forms of transport. Depots which are to remain in the same place for any length of time should always be inspected and checked periodically, and any deficiencies should be reported immediately.

Sales depots

Sales depots are maintained for the storage, sale and issue of timber. The sites are generally permanent and the property of the Forest Department, and they should, therefore, be well demarcated and properly fenced, preferably with treated wooden fence posts and barbed wire. A properly treated fence post should remain in good condition for twenty-five years or more. If treatment facilities are not available, then only the most durable woods should be used with the sapwood removed.

As regards the site for a sale depot the following factors have to be taken into consideration:—

(1) Its proximity to some main line of transport. For preference it should be near a railway station or port. If there are some good shade trees on the site so much the better.

(2) The site must be sufficiently large to store the maximum quantity of timber likely to be dispatched from the exporting divisions, and the necessity for providing room for extension should be kept in mind.

(3) The site should be well-drained. A damp depot always results in the rapid deterioration of timber from fungus attack, besides making handling and transport more difficult owing to the soft ground.

(4) Adequate facilities for the incoming and outgoing of timber should be provided.

In river depots the landing of timber is often a very slow business. It is, therefore, advisable to increase the frontage of such depots along the stream, so that landing can go on simultaneously along a long frontage, thereby enabling the timber to be cleared from the boom as fast as it arrives.

Management of Depots

Sufficient has already been said with regard to the control of transit depots. This paragraph applies to sales depots only. Details of management vary in different localities, but the following instructions are applicable in the main to all depots:—

Lay-out

Depots should be divided into separate plots for each species of timber. Different classes of timber such as sawn timber, logs, and firewood should also ordinarily be stored separately. In the case of a depot situated on a river, logs should be located where the least amount of dragging is involved. Species plots should if possible be further subdivided, so that different sizes of timber can be stacked separately. The various compartments in a depot should be separated by passages sufficiently wide to afford easy inspection, and it is usually necessary to provide one or more broad tracks to allow carts to pass through.

Stacking

Subject to the provision of facility for inspection, stacks should be as close as possible for the sake of economy in spacing. Logs should be arranged in neat

lines by species and classes. Should it be necessary to pile them, care should be taken that only logs of the same classification are put together, and the details of their measurements should be given on the ends of the logs. It is of the utmost importance not to expose sawn timber to the sun for longer periods than can be helped. This class of timber is usually stacked in piles of one hundred pieces or some other convenient number, and there should be an interval of only about two feet between the ends of stacks in order to afford protection from the sun to the ends of the scantlings. Not more than two scantlings in each stack should be in direct contact with the ground. Fuller information on the subject of stacking timber is given in Chapter VIII.

Classification, measurement, booking

As soon as any consignment of timber arrives at the depot it is measured, classified, and marked. The importance of accurate classification cannot be overstressed; well-graded timber will always sell better than timber which has been carelessly classified. Timber is entered up daily in the depot books and registers, whenever depot stocks vary from day to day.

In conclusion the following rules are important, and should be followed in all depots:—

(1) Never place good timber and inferior timber in the same lot.
(2) Do not attempt to hide defects as the purchaser is quite sure to discover them.
(3) Butts should be laid one way in a regular manner, and logs of equal size lotted together.
(4) Lots of approximately equal size and value should be made.
(5) Abide strictly by the depot classification, which should be hung up for public inspection.
(6) All lots should be numbered and accurately measured and booked, so that there can be no argument or confusion.

Stock-taking

Depots should be checked and the books balanced at intervals of a few months and reports submitted to the proper authority.

Protection

Adequate precautions to protect the depot from fire and theft must be taken. Chips and refuse wood must not be left lying about.

Clearance

Timber sold should be removed from the depot by the purchaser as soon as possible, and purchasers should not be permitted to use the depot as a convenient

place for storing their purchases. In the event of such storage being inevitable, special plots should be set aside at one end of the depot for leasing to purchasers of timber on adequate payment, but this practice should not be encouraged. It is also very essential to keep all timber depots clean and as free as possible of scraps of wood and bark. If such rubbish is left lying about, the liability to fungus and insect attack is increased enormously.

V

DISPOSAL AND SALE

SYSTEMS OF EXTRACTION AND DISPOSAL; general—working by Government agency—working by Government and purchasers combined—working by purchasers alone. SYSTEMS OF SALE OF FOREST PRODUCE; lump sum sales—payment on outturn. METHODS OF SALE; by private bargain—by fixed tariffs—by auction—by tender.

SYSTEMS OF EXTRACTION AND DISPOSAL

General

Systems for the extraction of forest produce from a forest and for its disposal afterwards are very numerous, but they can be classified under three main heads:—

(1) By Government agency.
(2) By Government and purchasers combined.
(3) By purchasers alone.

It is almost impossible to state definitely what special system is the most suitable, or even the most remunerative, for any given set of circumstances, as local conditions vary so much, and a system which is successful in one locality may be quite unworkable in another.

Amongst the considerations which must be taken into account before deciding on any system are the following:—

(*a*) The maintenance and improvement of the forest.
(*b*) A fair remuneration for Government.
(*c*) The prevention of theft or fraud on the part of the purchasers or forest employees.
(*d*) The safeguarding of the interests of the local population.
(*e*) The avoidance of unnecessary complications.
(*f*) The physical conditions of the locality.
(*g*) The number and qualifications of the forest staff available.
(*h*) The quality and quantity of labour available.
(*i*) The capabilities or financial standing of contractors or purchasers.
(*j*) The consideration of encouraging private enterprise.

The extent to which any of these factors is taken into consideration will differ according to the peculiarities of each case, and each set of circumstances must be judged on its merits.

Working by Government agency

Under this system the felling of trees, the collection of forest produce, the extraction of timber, and the disposal of all products is carried out entirely by Government, the net profit being the sale value less the working expenses.

The details of working may vary, but in general outline the system consists of extraction of the produce to a sale depot by persons working on behalf of Government, and the subsequent sale of the produce by Government.

Such systems are usually known under the name of departmental working, departmental extraction, etc., and are still practised in certain parts of India and Burma. In Burma, for example, departmental extraction of teak has been in vogue for many years in several of the most important teak divisions, but in other divisions teak is taken out by lessees who pay a royalty on the outturn. The most usual method of departmental extraction is for Government to pay contractors to fell and extract the timber to a sale depot where it is sold by auction, tender or direct sale. The work is paid for at rates stipulated in the contract, e.g. so much per cubic foot for felling, carriage and delivery at a certain spot in the required condition. Strict supervision is necessary over every detail of a contractor's work. The measurement and counting of timber for final payment must also be carried out by a reliable officer, and a very careful record of logs passed and paid for must be kept to prevent fraud.

It is often advisable to give advances to contractors on departmental work, on good security, so that the work continues smoothly. Such advances can be given as part payment for work done.

The general policy of Government is, however, to limit departmental extraction and to encourage extraction by purchasers whenever possible. Departmental extraction has, however, certain advantages in that all operations are directly under the control of the forest officer, and it is specially useful where regular supplies are necessary, as in the case of firewood in some districts, or to keep down local prices where forest produce is scarce. It may also be employed where a new industry has to be started or where a new product has to be placed on the market, and finally it is a system which can be well employed if it is thought that Government is not getting the full benefit from its forest produce under any other system.

As a rule, minor forest products are not extracted by departmental agency, but in special cases where it is considered that it is best in the interests of Government to do so, the system is sometimes practised. As an example, the collection of pine resin in the Himalayas may be quoted. In this case, the detailed nature of the work would never be complied with by an outside contractor, and in the interests of the forests themselves, apart from the remuneration received, it is advisable for Government to keep the work in their own hands. Another example

is that afforded by the collection of myrabolams in the Bombay forests. Prior to 1880 collection of myrabolams was farmed out to contractors, but a change-over to departmental collection resulted not only in greater remuneration to Government, but was also much appreciated by the forest tribes, who benefited considerably from the change. In this instance, the pendulum again swung back in the other direction in late years, and in most divisions the collection of myrabolams is now farmed out to reliable contractors.

The drawbacks of a system of departmental working are:—

(1) The large amount of work entailed, both executive and clerical;
(2) The bringing of a Government department into direct competition with private firms; and
(3) The commercial nature of such work, which is better suited to private enterprise than to Government officials.

Working by Government and purchasers combined

This system is sometimes adopted when it is in the interests of Government to have control over part of the work to be undertaken. As an example, it is often necessary that great care should be taken during fellings to avoid damage to the forest, and in such cases the actual felling of the trees may be done departmentally, while the timber is later extracted and sold by purchasers. This system has been adopted from time to time in India and may be usefully employed in thinnings, the trees being felled by skilled woodcutters paid by Government, and removed, after felling, by the purchasers. The system is also useful in improvement fellings, and ensures that no inferior or harmful trees are left standing, and that as little damage as possible is done to the growing stock.

Working by purchasers alone

The felling and extraction of trees and the collection of other forest produce by the purchasers themselves is by far the most common system of working adopted in India.

There are a great many varieties of the system, depending mainly on the different way in which payment is made. These will be described in the following pages on the sale of forest produce.

This system has the great advantage of relieving the forest staff of unnecessary work, and in addition encourages healthy competition. The first is a matter of no small importance in a country like India where the forest staff often have very large areas to look after, and where they can be far more usefully employed in the maintenance and improvement of the forests, rather than in being tied down to superintend work which could possibly be done better by private enterprise.

In the main, therefore, working through purchasers is usually the most satisfactory from the Forest Department's point of view, provided there is no lack of demand or competition and no silvicultural problems to be considered.

Systems of Sale of Forest Produce

There are many different methods under which timber and other forest produce may be disposed of to purchasers, but for the sake of convenience they may be grouped under the two following main heads:—

(1) Lump sum sales.
(2) Payment on outturn.

Lump sum sales

Under this head come all systems of sale when a fixed sum is paid down for the produce in question, whether the exact quantity of such produce is known or not. For example, Government may wish to sell a fixed number of logs from a depot, or a certain quantity of other forest produce collected departmentally. The usual procedure in such cases is to make these sales by auction. The sales may on the other hand be made by means of tenders or by direct sale. In the same way, the sale may be of some unknown quantity of produce. In this case the purchaser usually buys a licence or permit to collect and extract such produce from a specified area of forest for a fixed sum, the exact amount of produce extracted being unknown at the time of purchase. The purchaser then has the right to extract, under specified terms, as much produce as he can from the forest in question. Under this heading also comes the sale of a lease or a contract for the extraction of marked trees, provided the purchase price paid is by lump sum payment. In actual practice the sale price is usually realized in instalments (generally three), the first instalment being paid before the work is started or at any rate before any extraction of timber is allowed. The system has both advantages and disadvantages, depending on the actual circumstances of each individual case.

Where the exact amount of the produce is known, as for example in the sale of timber, fuel or minor products at a depot, it is obviously the only reasonable form of sale to adopt, but in the case of standing trees or other produce of unknown quantities, it is sometimes open to objection, as the payment made may be quite out of proportion to the amount of produce extracted. On the other hand it is very often the only means of getting such produce extracted, and if the volume of standing trees or other produce is known with fair accuracy, this method of sale is considered by many to be the best.

Payment on outturn

Under this head are included all sales when the amount paid corresponds with the actual amount of produce sold or extracted. There are many varieties of this type of sale, including the well-known royalty systems where an agreed amount is paid by the purchaser per unit of produce extracted. This royalty may be on volume, weight, quantity or *ad valorem*, and may or may not include a guarantee of the outturn to be expected. Systems of working are, however, so closely inter-connected with systems of sale that the following more common systems of extraction and disposal of forest produce are explained briefly to give an idea of some of the varieties that are adopted in India.

(1) Sale of a whole coupe or area

In this case the sale usually consists of disposing of the right over a given area to one person or firm, known as the lessee, to extract timber or other produce for a fixed period, which may extend to one or more years. The sale value is realized either in a lump sum payable in one amount or by instalments, or by payment of royalty on the produce extracted, or by a combination of both. The simplest form of lease is that in which a lump sum is paid for the privilege of extracting as much produce of a certain kind as the lessee can obtain in a given time. This system is obviously not applicable to timber or fuel, as the forest would soon be ruined, but it is admirably suited to the sale of such annual crops as grass, fruits, and lac. This simple form of lease is sometimes known as 'farming', and is one which can often be conveniently employed where there is no danger of future crops suffering from such a form of collection. It is, however, a most dangerous system under certain circumstances, such as for instance the collection of dead timber, where the temptation of the purchaser to ensure for himself a large amount of dead timber by killing living trees is usually more than he can resist. The granting of a lease for more than one year to the same purchaser may or may not be advisable. It depends entirely on the circumstances. In the case of lac, for example, if a lessee knows that he is going to have the right of collection for some years he will be careful in seeing that sufficient brood lac is left on the trees to ensure a good crop the following year. On the other hand the right of collection of dead wood should be confined to definite short periods and to definite coupes, so that the lessee has no inducement to kill living trees.

(2) Sale of marked standing trees

This is one of the most suitable and profitable systems of disposing of trees in a forest. The trees are selected and marked, and the whole outturn is sold either by auction, tender or direct sale. Payment may be made in a lump sum,

by instalments, or by payment of royalty on outturn. The number and cubic contents of the trees sold may or may not be known when the contract is made. In Burma, for instance, a system is commonly employed whereby teak is felled and extracted by large firms, who obtain a lease to extract girdled trees in a specified area during a specified time, which usually runs into a number of years. The teak trees are selected and girdled, under silvicultural rules by forest officers, and are then allowed to stand for two years so that the timber will become light enough to float. The lessee is then permitted to start work, and royalty is paid per cubic foot, or per ton of fifty cubic feet, on all timber extracted. After the payment of royalty, the timber is the property of the lessee. In this instance the exact number of trees to be felled and extracted is not known when the lease or contract is fixed up, and the purchaser is paying on outturn. In other cases, the exact number of trees to be felled and extracted may be definitely known. In such cases, the trees are selected and marked and the probable outturn is estimated by the forest official. The trees are then sold either as selected trees or more commonly as a coupe. The sale may be by auction, tender or private bargain, the purchaser estimating the price he can pay by his personal view of the case. The price will be influenced by the situation of the coupe or trees, which affects the cost of extraction, the current market rates of timber, and whether the purchaser considers the official estimate to be high or low. If he considers that he can get more timber out of the trees than the official estimate and if the market rate of timber is on the upward grade he will pay a better price, and the same is the case if extraction is easy and if the purchaser is of opinion that he can work the contract economically. A well-known variety of this system is the 'monopoly system', where the price paid for the coupe or trees is known as the monopoly price, as it gives the purchaser the right to fell and extract the timber. In addition to the monopoly price, however, the purchaser has to pay royalty on all the timber brought out of the forest. One disadvantage of this system is that the purchaser is not always induced to remove inferior timber if the royalty rates are at all high, but if royalty rates are kept low it has the advantage of inducing the purchaser to extract everything he possibly can if he can see a profit on it. The fixing of royalty rates is, however, not an easy matter, as extraction costs may vary considerably in different parts of a forest, and while a purchaser may see his way to extract inferior timber from one part of his area and pay royalty on it with a probable profit to himself, he may find it impossible to pay the same royalty on such timber from another more distant and more difficult part of his area, with the result that he leaves the timber in the forest. In such cases, therefore, it is often better to dispense with royalty and to confine the sale to a lump sum purchase when it is in the interests of the purchaser to bring out all the timber he can whether good or bad,

as he has paid his price, and he will in consequence endeavour to secure the greatest possible outturn for his money.

(3) Sale by means of licences and permits

The method of sale by licences and permits is widely adopted in India, and there are more varieties of this type of sale than of any other form of sale practised in this country. The most typical method is for an intending purchaser to apply for a licence to extract timber or other forest produce in a specified area during a fixed period of time, a fee being paid for the licence. The licence holder then proceeds to collect and extract his produce, which is usually checked on leaving the forest to see that the terms of the licence have not been abused.

In actual practice, there are many modifications of this type of sale according to local conditions. For example, a licence to extract valuable timber should only be issued by a responsible officer to a responsible purchaser, while a licence for petty forest produce may be issued by low-paid officials or even by persons specially employed for the purpose, the latter being paid either by a fixed salary or by commission on the revenue collected by them. For such petty produce there is usually a fixed unit of sale, as for example so much per head-load of grass or per cart-load of fuel or bamboos. In any case, the exact amount of produce which can be extracted should always be made clear and should be entered on the licence, so that no complications may arise later. A common example of the use of this system of sale is the issuing of shooting licences, in which the purchaser obtains the right to shoot in a specified area, often termed a shooting block, for a definite period, which may vary from one day to one year; the number of large game which he is permitted to shoot being specified on the licence, which is usually called a shooting pass or permit.

A common variety of the licence system is that known as the computation system, in which the issuing of many licences or permits for short periods to several persons is commuted by one payment. The system is very useful in the case of issuing permits to villagers to extract petty forest produce, as instead of having to issue many separate permits to individuals, one permit covering the whole village can be issued, thereby saving considerable trouble in checking and supervision. The system is, however, one that should only be adopted in the case of petty produce such as thorns for village hedges, litter, grass, and forest grazing, and is not ordinarily extended to valuable products unless for bona fide domestic purposes, and then only for a specified short period.

Sometimes, permission is given for persons to enter reserved forests, without previously having purchased a licence, to collect forest produce of certain specified classes and to pay for the produce so collected when it is taken out of the forest. This system is, however, only applicable in remote tracts from which it is possible

to remove the produce only by one or two well-defined routes. It is not a system to adopt unless circumstances are such that no other system is applicable, and at the present time it has practically gone out of use, except possibly in some very remote districts, or where the produce is brought to a Government sale depot, and the collectors are paid for collecting it.

Finally, there are some cases where it is very difficult for the Forest Department to collect any revenue at all from certain types of forest produce, and special means have to be adopted in order that Government may get its share of the sale of such products. An example of this is the production of cutch, lac, and rubber in the large areas of unclassed forests in Burma. These forests belong to Government, but are not reserved forests in the usual sense, and anyone can fell trees, other than teak, in such areas without payment. Cutch (*Acacia catechu*) trees are often so felled and the wood used for making cutch, on which it is practically impossible for Government to collect any revenue as there is no direct control. As practically all the cutch made in Burma is exported, Government has adopted the system of collecting an export duty on it at the seaport towns, and in this way they derive a return for this forest produce which otherwise would bring them no revenue. The Forest Department in such instances is not directly concerned with the levying of the export duty, but it is an example of how revenue can be collected in exceptional cases where the collection by other means is not a practical proposition.

Methods of Sale

The common methods of selling forest produce are as follows:—

(1) By private bargain.
(2) By fixed tariffs.
(3) By auction.
(4) By tender.

By private bargain

This method of sale is the most common method employed in ordinary business transactions, but is not one which is commonly adopted in forest work except under special circumstances. It is applicable to cases where one person or firm desires to purchase some produce for which there is no general demand, as for example when a few selected trees or logs are required for some particular industry. In some such cases, the price may be fixed according to current market rates or past sales, but in others the price may not be known, and the official conducting the sale has to use his own discretion, in which case it may be advantageous to accept a low price for produce for which there has been no previous

demand, in the hope that it will encourage others to buy later. But in each sale of this kind a knowledge of the probable demand is an advantage, and the individual circumstances must be well considered before a decision is arrived at. The system may also be adopted to break up 'rings' or combinations of buyers at auctions, and on several occasions in India this method of sale has resulted in the discomfiture and collapse of well-organized rings of timber buyers who tried to force down prices at sales of forest produce.

By fixed tariffs

This method of sale is similar to sale by private bargain, except that the prices are fixed beforehand and cannot be altered except with official sanction. Prices must, therefore, tally approximately with current market rates, and they have to be revised from time to time accordingly.

This method of sale is a common one in all parts of India, especially for inferior timber, firewood, bamboos, and minor forest produce. In depots especially the method is widely adopted, as it needs very little supervision and can be conducted by subordinate staff, the periodic checking of stocks and sales being all that is necessary.

The well-known royalty system is really an adaptation of this method of sale, the royalty being a fixed tariff on all produce extracted from the forest. The method is recommended for its simplicity and is particularly applicable in a country like India where forest produce of all kinds is much in demand for the daily requirements of the people.

By auction

Sale by auction literally means sale by 'increasing', which implies that the intending purchasers go on increasing the price they are prepared to offer until no one offers any more, the highest price offered being accepted as the purchase price. The method is widely adopted for the sale of forest produce, and if there is plenty of rivalry and competition, auction sales are a very satisfactory and profitable form of sale. The one disadvantage of such sales is the danger of combinations or rings being formed to defeat the purpose of the auction, which is to encourage healthy competition and brisk bidding. If such a combination is formed amongst would-be purchasers, it is useless to pursue the auction, and the only remedy is to adopt some other method of sale such as private bargains. Combinations can, however, be checkmated to a certain extent by extensive advertising to attract purchasers from a distance who have no connexion with the local rings. The presence of one or two outside purchasers is usually quite sufficient to break up a local ring, especially if the outsiders are buying up bargains which the local traders would like themselves.

Sometimes, in order to prevent unreasonably low prices, a reserve price, known as an upset price, is fixed, below which no bids are accepted. This often has a salutary effect, as it shows would-be purchasers that lots will be withdrawn if fair bids are not offered.

A variety of the true auction sale is that commonly known as a Dutch auction. In this form of sale a commencement is made with a high price, and lower prices are called out from time to time by the auctioneer until someone accepts the price and the sale is completed. This, though not strictly an auction in the correct sense, occupies more time than a true auction and is not adopted to any extent in India, though it is popular in some parts of Europe.

By tender

Sale by tender is a not uncommon form of sale in India. It consists in would-be purchasers offering on or before a fixed date the price which they are prepared to pay for the product in question. There are two different forms of tender known as 'sealed tenders' and 'open tenders'. In the case of sealed tenders the intending purchasers submit their tenders in sealed covers, with the result that no other intending purchaser knows what the offer is. In the case of open tenders, offers may be made at any time before a certain date, either personally or in writing, so that the price offered is known to anyone interested. This may result in bargaining and, in addition, tenderers quickly get to know the probable price that will be accepted and can combine accordingly. It is, however, a valuable method for produce whose value remains fairly constant, and can sometimes be employed for breaking up combinations at auctions.

Sale by sealed tender, on the other hand, is a good method of sale as it gives little trouble and is always effective in breaking up combinations. It is not always so profitable as other forms of sale, such as auctions, but as the right to accept or reject any tender is always reserved to the seller, it gives the seller the advantage of being able to select the buyer, and enables him to disregard doubtful or undesirable tenderers. It is a common practice in all forms of sale by tender to demand a deposit with the tender. This has a salutary effect in that it confines the tenders to genuine traders and checks any tendency on the part of the tenderers to back out of their offer.

VI

ORGANIZATION OF FOREST LABOUR

General—Wages—Supervision.

General

In India, local conditions of labour vary much from place to place, and in some localities little difficulty is experienced in obtaining labour for forest work, while in others it may be a formidable task to collect experienced workers.

In places where they exist, forest dwellers make the most satisfactory forest workmen for they are born to a forest life. On the other hand, they are often very lazy. In India generally, there is usually no necessity for maintaining permanent forest labour, as the country is mainly agricultural and the people are largely familiar with forest work and especially with the use of the axe, and often with the saw too.

Labour is, however, often irregular, especially when crops have to be harvested or sown, and at these times it is often difficult to get labour for forest work, and routine cannot proceed smoothly throughout the year under such circumstances.

Ordinarily it is easier to find labour in districts which are not self-supporting, and when the local population has to earn money to buy food and the other necessities of life beyond those that they themselves can produce.

In hill districts, the population is often so sparse that it is necessary to import labour, and in the plains too this is sometimes necessary. Imported labour generally means increased expenditure and trouble and should be avoided if possible. In the Himalayas, imported labour is generally recruited and brought to the forests by a contractor, who is paid a commission for doing so, the commission being in the form of a percentage of the earnings paid at the conclusion of the work. Speaking generally, therefore, forest labour can be divided into the following classes:—

Local labour, which is often of a casual and fluctuating nature, collected by local forest subordinates from surrounding villages. Such labour is often employed regularly every year on such work as making up forest roads, clearing fire lines and departmental burning.

Imported labour, which may come and settle in the forest for one season or possibly more, but never permanently. Such labour may be collected depart-

mentally or by contractors, and is often employed on extraction and conversion work.

Forest villages or settlements. This labour is of a permanent nature, specially located at selected centres in or near the forests, and under an obligation to work in the forests when required to do so. In Burma, forest villages often move from place to place under a special system of management known as *taungya*, or shifting cultivation. These villages clear selected forest areas every year and raise crops on them. At the same time they help in raising a plantation on the same area, and after the plantation is established they move on to another site where the procedure is repeated. The system has the advantage of providing permanent forest labour within certain limits and under a certain amount of control.

Wages

The question of wages is often a very serious problem. It is essential to pay labour a fair wage, whether it be for daily labour or for piece-work. Underpaid labour will be dissatisfied and will finally go away, while overpaid labour will become lazy, and give a poor return, apart from the pecuniary loss incurred. Wages once raised have a tendency to continue to rise, or at any rate to result in demands for further rises. Local conditions such as unusually difficult conditions, remoteness of the forests, and the prevailing cost of food-supplies, all have to be taken into consideration in deciding a fair wage. The degree of skill required has also to be gauged, as it is clear that men who are really skilled in a special line of work deserve better wages than those who have no such qualifications. The system of payment is usually one of the three following:—

(1) *By daily labour.*—Daily labour is usually employed when labour is required for ordinary forest work not connected with timber conversion, e.g. work requiring special supervision by the forest staff, such as weeding, planting, road-construction, etc.

(2) *By piece-work.*—This is the usual method employed in departmental timber operations, for extraction of timber for local use, and occasionally for road work, where payment is made per unit of work done, e.g. volume of earthwork excavated. This method requires a careful check of the outturn, for it induces labour to work rapidly often at the expense of quality, and it is usual to fix a standard of specification for timber converted which must be adhered to before the pieces can be passed for payment. Felling is often paid for on a scale based on diameter or girth. Seed collection is another example where payment can be made per unit of seed collected.

(3) *By contract.*—Contract labour is usually employed on building and road construction of considerable magnitude. Supervision is necessary to see that the terms of the contract are carried out, and that work is up to specification.

Supervision

Finally, it will not be out of place to mention that the efficiency, as regards quality and quantity of outturn of any labour employed in a forest, leaving out of consideration any special aptitude for the work, depends to a very great extent on the supervision of the forest subordinates in charge of the work. Forest Range Officers, Forest Guards, and Foresters have a great influence on all forms of forest labour. The choice of a good foreman is also important, and even the most unruly gangs of workmen can more often than not be persuaded to do good work if properly handled. The status of labour is changing nowadays all over the world, and tact and discretion are often necessary to avert calamity and to get the best out of any labour. Personal contact with the workmen is essential with any forest official, and strict justice tempered with kindness is the only attitude to adopt. The days of task-master and slave have gone, and it is the duty of every forest official to study his labour questions with care. It is only by this means that he will get the best out of his men, and will at the same time benefit the forests under his charge and bring credit to himself and his department.

VII

THE USES OF WOOD

GENERAL. CONSTRUCTIONAL WORK; buildings—bridges—other superstructures. FOR USE IN CONTACT WITH THE GROUND; railway sleepers—piles—house posts—fence posts—telegraph, telephone, and transmission poles—mine props—paving-blocks. FOR USE IN CONTACT WITH WATER; marine piles—fresh water piles. SHIP- AND BOAT-BUILDING; general—hulls (excluding dugouts)—deck planking, outer planking, linings, etc.—masts and spars—oars and helms—keels, stern- and stem-posts—dugouts—rafts and life-saving apparatus. JOINERY AND CABINET-MAKING; joinery—cabinet-making—chairs and camp furniture—veneers and plywood—parquetting. VEHICLE PARTS; railway carriages and wagons—carts and carriages—motor-car bodies—aeroplane members. TOOL HANDLES; carpentry tool handles—axe, pick, and hammer handles. BOXES, CRATES, AND PACKING-CASES; tea boxes—opium chests—rubber chests—candle boxes. MATCHBOXES AND SPLINTS. SPLITWOOD; cooperage—tent pegs, trenails, railway keys, etc.—other uses. SPORTING REQUISITES; billiard cues—bows and arrows—cricket bats—croquet balls and mallets—fishing rods—golf clubs—guns and rifles—hockey sticks—lance and spear shafts—skis—tennis racquets. MISCELLANEOUS USES; agricultural implements—bearings, brushes, and rollers—bentwood articles—bobbins, picker arms, shuttles, etc.—boot lasts and trees and wooden shoes—brushes and brooms—carving, toys, combs, etc.—cigar boxes—engraving—figure cutting—mathematical and draughtsman's instruments—musical instruments—pencils and penholders—picture frames—sticks, umbrella handles, and police batons—tobacco pipes—turnery. FIREWOOD. PULPWOOD. WASTEWOOD; sawdust—shavings—wood wool.

GENERAL

It is doubtful if there is any product of nature which varies more in texture, appearance, and utility than wood. In everyday life its importance cannot be overestimated. Wherever one is and wherever one looks, wood or the products of wood are in evidence. In the house, it is visible in every direction, and out in the open, in towns or in the country, its varied uses can be seen on every side. Some countries are richer than others in the variety of their indigenous timbers, and India is one of the richest in this respect. In Great Britain, for instance, there are only about 40 species of indigenous timber trees. In America, there are some 200. In India, there are more than 2,500, and Sir Joseph Hooker refers to the flora of India as 'perhaps the richest, and certainly the most varied, on the surface of the globe'. With such a superabundance of woody species to select from, there is a wide choice for anyone requiring timber for some specific purpose,

and as woods vary so in their technical properties it is not always easy to choose the best wood for the purpose in view. There is, in fact, an embarrassing richness about the woods of India, which makes a correct selection a matter of greater difficulty than if there were fewer species to choose from. In the past, India solved this problem of selection in the most obvious way. Her people soon discovered which were the most common timbers in each locality, and which of these timbers appeared to be the best for all ordinary purposes, and these were the woods they used for their everyday needs. This worked very well while the supply of these timbers lasted, but gradually the demand overtook the supply, and India was confronted with the possibility of her forests being denuded of the well-known species. Fortunately, the Indian Forest Department came into being in time to ward off disaster, and a continued supply of timber is now assured so long as forest conservancy is maintained.

At the same time, the demand for wood and wood products continued to grow, and it soon became evident that India would have to look to her lesser-known species to make up the deficit.

Amongst the 2,500 woody species which are known to exist in India, there is naturally a wide range. For example, a timber which is suitable for high class cabinet-making, where handsome figure and colour are required, is obviously wasted if used for underground piles, railway sleepers or pit-props. Every use to which wood is put has its special requirements, and the suitability or otherwise of any wood depends, in the main, on its technical properties. The most important of these technical properties are the following:—

1. Anatomical structure.
2. Shape and size of trees.
3. Specific gravity or weight.
4. Strength.
5. Hardness.
6. Flexibility.
7. Elasticity.
8. Toughness.
9. Adaptability or otherwise to seasoning.
10. Durability.
11. Colour, grain and figure, and similar characteristics.
12. Freedom from defects.
13. Adaptability for being worked with tools and on machines.

If all these technical properties are to be taken into consideration, the allotment of any species to its proper sphere of work is not, therefore, the work of a moment. It requires years of patient research and trial, and an expert knowledge

of the vagaries of wood, combined with scientific methods and apparatus for carrying out the tests. In India, the investigation of the technical properties of Indian woods is the work of the Utilization Branch of the Forest Research Institute at Dehra Dun, and for the past 20 years a steady and progressive investigation into the possibilities of the woods of this country has been proceeding.

As the work of research and trial has progressed, it has become more and more evident that India possesses timbers which are unsurpassed in any other country, but that those which are in common use are so few in number that they could almost be counted on one's fingers. In addition, the few that have been in common use are in many cases used for all purposes, regardless as to whether they are really suitable or not, and up to a few years ago no serious attempt had been made to remedy this unsatisfactory state of affairs.

The timbers which were in most demand for all ordinary purposes were teak (*Tectona grandis*), sal (*Shorea robusta*), deodar (*Cedrus deodara*), sissoo (*Dalbergia sissoo*), chir (*Pinus longifolia*), semul (*Bombax malabaricum*) and toon (*Cedrela* spp.); with a few others such as Indian rosewood (*Dalbergia latifolia*), walnut (*Juglans regia*), *pyinkado* (*Xylia dolabriformis*), sandal (*Santalum album*), sundri (*Heritiera* spp.), and padauk (*Pterocarpus dalbergioides* and *Pterocarpus macrocarpus*) with a limited demand.

Of the well-known woods, teak, sal and deodar stood out pre-eminent. Teak supplied the demands of Burma and South and Central India, sal covered the major requirements of the east and north, while deodar was the mainstay of the far north and Himalayan tracts. All three timbers had been proved to be good general utility woods, and were available in what appeared to be unlimited quantities. In addition, all three had one important characteristic, especially in a country where wood-destroying insects and fungi abound; they were durable. It is interesting to note, at this juncture, what an important factor the durability of wood is, and how great a part it plays in the utilization of timbers. It is only natural, of course, that the users of timber should select the wood which will last the greatest number of years, when employed for house construction or any other purpose, if recurring expenditure on renewals is to be avoided; and even in these more enlightened times when other characteristics have assumed a larger share of attention, durability still plays a leading part. Fortunately, science has been able to improve on nature in this respect, and woods which are not naturally durable can be rendered more durable even than nature's best, by artificial preservative treatment.

So long, therefore, as supplies of the common durable woods were plentiful at low prices, Indian timber users looked no further for possible substitutes. Of the most common durable timbers teak was in most demand, and its reputation spread, not only throughout India, but throughout the world. The reason for

the great reputation which teak achieved will be discussed on page 137. Suffice it to say that teak is what might be called a foolproof wood, and its durability and adaptability soon gave it a reputation which bid fair to eclipse all other woods in the country. Not that teak is a suitable wood for all purposes—it is not, and there are several other woods in India which, for certain purposes, are far superior to teak. However, with such a wonderful wood in plentiful supply for general utility purposes, Indian users looked no further for possible substitutes, until the inevitable began to happen, and the demand started to overtake the supply, which in turn became more and more restricted, resulting in a rapid rise in price. The Great War was an important factor in this connexion, and the demand for timber rose with such alarming rapidity at that time that India, as well as other countries, had to look to her resources of other woods to satisfy the increasing demand caused by this world-wide cataclysm.

The much-needed stimulus having been given, India soon woke up to the possibilities of what have frequently been referred to as her 'vast forest resources', and the study of her lesser-known woods was taken up in earnest. Good progress has already been made, and considerably more is now known about these woods than was known 25 years ago. The choice of species is, however, so very large that a considerable number of years must elapse before India can say that she is well acquainted with the possibilities of all her timber resources. In addition, important factors such as enumeration of stocks, regeneration, and extraction, all play their part in the successful exploitation of a given species, and it is a waste of time to investigate the possibilities of a species of which stocks are too limited to be of importance, or which cannot be successfully regenerated, or extracted from the forests with reasonable facility. The choice of commercial possibilities is, therefore, limited by these factors, but even then the remaining number of species is sufficiently large to cause embarrassment. In addition, the number of uses to which wood can be put is so great as to make it impossible to specify the best wood for every purpose. Using commonsense and a proper estimation of comparative values it is, however, possible to arrive at a close idea as to what woods are likely to be the most suitable for any specific purpose. In the following pages will be found some comprehensive lists of the more common uses to which wood in India is put, and by a sagacious estimation of the various factors involved, it should not be difficult to select from these lists the best timber for any specific purpose in any given locality.

Constructional Work

Constructional work comprises one of the biggest uses to which wood is put, the largest consumption belonging to superstructures, which include all parts

of a structure not actually under or in contact with the ground or water. In the main, superstructures refer to buildings, but this heading includes also such other works as bridges, scaffoldings, derricks, and similar erections.

Buildings

The quantity of timber used for this type of work is always very large, and in a well-forested country like India, it is exceptionally so, and although it is quite impossible to estimate the amount of timber actually used in India every year for buildings there is little doubt that the total consumption exceeds that of any other industry.

The chief requirements of a good constructional wood are *strength* and *durability*, when required for use as main members. In house construction, all joists, beams, and rafters require to be strong, and durability is equally important whether the timber is exposed to the elements or not. Durability in fact, is, in a country like India, a most essential factor, and unless a timber is really durable, and reasonably immune for a number of years from attack by termites, borers, and fungi, it is best to treat the wood with a good preservative, and for external work preservative treatment is almost a necessity, except in the case of a few naturally durable timbers such as teak, sal, and deodar.

For internal work such as door and window frames, floorings, staircases, ceilings, etc., the relative importance of different characteristics varies with the type of work to which the wood in question is to be put.

In floorings, for example, *strength*, *durability*, *steadiness*, and *hardness* are important features, while in the case of light doors they are not so important. In the latter case, *lightness* is a desirable feature, and where the woodwork of a house is to be left unpainted or unstained, *appearance* is often important. In the case of outdoor superstructures such as permanent derricks, *great strength combined with durability and lightness* should be aimed at, while in temporary structures, durability is not so important. It will be seen, therefore, that each case requires individual consideration of the factors involved, and that no hard and fast rules can be laid down. In addition, *availability and price* are always items which play an important part in the selection of a timber for any specific use. Speaking generally, a local wood, or one which is at any rate easily obtainable, would have preference over a slightly better timber growing at the other end of the country, and in comparatively few cases would it be necessary to resort to far distant or foreign woods. In India, the choice of good constructional woods is very wide. The three timbers which stand out pre-eminently are teak, sal, and deodar. The reason is not far to seek. They are all reasonably strong, sal wood being exceptionally so; they are all naturally durable; and

finally, they are all plentiful in the areas where they grow, and have become popular through continued use extending over centuries.

There are, however, many other Indian woods commonly used for building purposes and other constructional work. Some are definitely suitable for the work they are used for, others are not. The following list, though covering but a small proportion of the woods actually employed for this purpose, is fairly representative, and will be sufficient to act as a guide to anyone seeking the best timber for building and construction work in the district where the timber is required.

Abies pindrow (fir).—Weight 33 lb. per cu. ft. (air-dry). The wood is white and soft, and has no distinctive smell. It is easy to work and finishes smoothly. It usually has a fair number of knots, but it is an excellent and useful light wood of the 'deal' variety which can be employed with satisfaction for all internal work. It is not, however, a durable timber, and should be treated with a preservative if required for external use or where liable to be attacked by fungi or insects.

Acacia arabica (babul).—Weight about 52 lb. per cu. ft. (air-dry). A very hard and fairly durable wood. Excellent for house posts, and for such purposes as flooring, where hardness is an asset. Can be ranked amongst the best of India's naturally durable hardwoods, where its special features are required.

Adina cordifolia (haldu).—Weight 40 lb. per cu. ft. (air-dry). A fine close-grained wood for internal fitments. For such purposes as bathroom, bakery, dairy, and kitchen fitments, it could not be bettered. It is a clean, pale yellow wood of fine texture and can be easily cleaned by washing and scrubbing. It is only moderately strong and is inclined to be brittle when cross-grained and should not be used for external work as it is not very durable.

Albizzia lebbek (kokko).—Weight 44 lb. per cu. ft. A fairly strong and durable wood, which can be used with advantage for most structural purposes. Selected timber can also be very handsome, and for flooring, panelling, and heavy furniture it has a proved worth above the average.

Albizzia odoratissima (black siris).—Very similar to kokko but slightly heavier and harder.

Albizzia procera (white siris).—Similar in appearance to the other two *Albizzias*, but not so heavy. It is, however, stronger than kokko and deserves more recognition than it has had.

Anogeissus acuminata (yon).—Weight 55 lb. per cu. ft. (air-dry). A timber which has come to the fore during the last few years on account of its strength and elasticity. It is a dull creamy grey colour and is straight-grained and

extremely hard. It is available in fairly large quantities from Burma, and is a timber which could be used with advantage where strength and shock-resisting ability are required.

Artocarpus species (chaplash, aini, jack and lakooch).—Weights vary between 34 and 40 lb. per cu. ft. (air-dry). Good medium-weight woods of proved utility. Chaplash is suitable for interior and ornamental work. Aini has the reputation of being the best substitute in India for teak. It is a very durable wood and very easy to season. It does not warp or crack, and equals teak in strength while being slightly lighter in weight. Jack also is a sound wood and, when available, can be used with confidence for interior work of all descriptions. Lakooch is the heaviest of the quartet, but is also the most durable and is much prized for house posts, rafters, and beams, as being highly resistant to termites and other insects.

Berrya ammonilla (trincomalee wood or *petwun*).—Weight about 64 lb. per cu. ft. (air-dry). A hard Burmese wood of renowned durability and resistance to wear and tear. Recommended for use where great strength, weight, toughness or durability is required.

Bischofia javanica (bishop wood).—Weight 35 lb. per cu. ft. (air-dry). A useful structural wood for general utility purposes. Somewhat weak, easily worked but durable, especially in contact with water.

Calophyllum species (poon).—Weights from 41 to 48 lb. per cu. ft. (air-dry). The outstanding feature of these woods is the size and length of the logs obtainable. They are already well-known as superb mast and spar woods, and are worth the notice of engineers and others who may require timbers of great length, combined with strength and elasticity. They should, however, be treated with preservatives if used in exposed positions as they are subject to attack by insects and fungi.

Cedrela toona (toon).—Weight 30 lb. per cu. ft. (air-dry). Probably the most universally used 'bazaar' wood in India, owing to its wide distribution and extensive cultivation as a shade tree. Being cheap, light, easy to work and quickly seasoned, it lends itself for use in small workshops, and although not very strong or durable, it is an excellent wood for backings, linings, panels, doors, cupboards, and similar work.

Cedrus deodara (deodar).—Weight 35 lb. per cu. ft. (air-dry). One of the three general utility woods of paramount importance in India. Extremely easy to season, saw, and work to a clean finish. Extremely steady and durable and one of the few timbers which resists termites. Has a strong aromatic smell and oozes resin from the knots even after seasoning. It is not, therefore, a good

wood for interior fittings and should not be used for painted or polished work, but is a timber of outstanding merit for all other structural and building work.

Chukrasia tabularis (chickrassy).—Weight 48 lb. per cu. ft. (air-dry). An excellent medium to light weight wood for internal fittings. Often very handsomely figured and never gives trouble after seasoning.

Dalbergia latifolia (Indian rosewood).—Weight 55 lb. per cu. ft. (air-dry). One of the finest cabinet woods that India possesses. Very strong and easy to work. Too good and expensive a wood for house members and ordinary work but excellent for interior fittings and furniture.

Dalbergia sissoo (sissoo).—Weight 50 lb. per cu. ft. A well-known furniture and general utility wood in North India. It is strong, elastic and reasonably durable. Can be used for all structural work with confidence, and selected wood makes exceptionally handsome fitments and panelling.

Dipterocarpus species (gurjun [*kanyin*], *eng*, hollong, etc.).—Weight 45 to 53 lb. per cu. ft. (air-dry). The timbers in this group are all typical constructional and general utility timbers. *Eng* is the heaviest and strongest, but the gurjuns are also good strong woods, not very durable but well-suited for building purposes, for roofing and for flooring, especially if treated. Prices are usually very moderate.

Duabanga sonneratioides (lampati).—Weight 28 lb. per cu. ft. (air-dry). An excellent timber for all general purposes. Deserves to be better known, but supplies are limited. Does not warp or split or 'move' badly after manufacture.

Hardwickia species (piney and anjan).—Piney weight 43 lb. and anjan 46–67 lb. per cu. ft. (air-dry). Two excellent general utility woods, and most suitable for beams, rafters, and house posts. Anjan is very heavy and hard, but it is also very durable and tough.

Heritiera minor (sundri).—Weight 65 lb. per cu. ft. (air-dry). A heavy and extremely strong, tough and durable wood, which can be used with advantage for heavy constructional work, house posts, and suchlike work.

Hopea species (hopea, Andaman thingan).—Weights from 39–73 lb. per cu. ft. (air-dry). Excellent general utility woods. Strong, tough and naturally durable and eminently suitable for all structural work.

Lagerstroemia species (jarul, benteak, Andaman *pyinma*, etc.).—Weights usually between 40 and 50 lb. per cu. ft. (air-dry). Another family of useful utility woods. Straight-grained, strong elastic timbers of more than average merit.

Mangifera indica (mango).—Weight 42 lb. per cu. ft. (air-dry). A useful cheap constructional wood. Moderately soft, strong, easy to work, but not very durable unless treated.

Mesua ferrea (mesua).—Weight 54–75 (average 60) lb. per cu. ft. (air-dry) for Assam timber and 67 lb. per cu. ft. for South Indian timber. An extremely hard, strong, and naturally durable wood, for all kinds of heavy constructional work.

Ougeinia dalbergioides (sandan).—Weight 55 lb. per cu. ft. (air-dry). A very sound tough and elastic wood which deserves more attention.

Parashorea stellata (tavoy wood).—Weight 43 lb. per cu. ft. (air-dry). Another excellent wood which deserves more attention. Is much prized in Burma as a first class structural timber. Should be treated if possible as not very durable.

Pentacme suavis (*ingyin*).—Weight 52 lb. per cu. ft. (air-dry). A strong durable wood.

Picea morinda (spruce).—Weight 29 lb. per cu. ft. (air-dry). An excellent substitute for 'deal'. Not naturally durable, but comparatively strong and very suitable for internal work.

Pinus longifolia (chir).—Weight about 35 lb. per cu. ft. (air-dry). A well-known pine wood which, next to deodar, is used more than any other wood in North India. Is not durable, but can be treated easily. An excellent all-round cheap 'deal' timber for internal fittings, matchboarding and similar work.

Pinus excelsa (blue pine).—Weight 32 lb. per cu. ft. (air-dry). A slightly superior wood to chir, and eminently suited for all types of work for which European and American 'deal' woods are used.

Pterocarpus species (Andaman and Burma padauk, bijasal, etc.).—Weights between 45 and 54 lb. per cu. ft. (air-dry). This family comprises some of India's most valuable woods. They are all very steady, strong, durable, and handsome woods and are unsurpassed for high class constructional or ornamental work.

Shorea species (sal, *thitya*, makai).—Weights vary from 37 lb. per cu. ft. for makai (*Shorea assamica*), to 65 lb. per cu. ft. for *thitya* (*Shorea obtusa*). Sal (*Shorea robusta*) is about 50 to 56 lb. per cu. ft. (air-dry), and is probably the best-known and most used wood in Central and East India. It is naturally durable, and the heartwood resists termites for many years. *Thitya* is harder and heavier than sal and just as durable. Makai is a much lighter timber and more suitable for interior work.

Tectona grandis (teak).—Weight 38 to 43 lb. per cu. ft. (air-dry). Burma and Malabar teak is usually fairly straight-grained and of even texture and colour. Central Indian teak is often well-marked with dark streaks and veining, and although more handsome, is weaker than teak from Burma and Malabar. They are all equally durable.

Terminalia species (laurel, kindal, white chuglam, hollock, etc.).—Weights vary between 39 lb. per cu. ft. for hollock and *badam* and 53 lb. per cu. ft. for laurel. The *Terminalia* family comprises several common and useful woods, most of which make excellent structural timbers. Their chief defect is a tendency to crack and split, but their availability will always ensure their continued use in the districts where they are found.

Xylia species (*pyinkado* and irul).—Weights 57 and 52 lb. per cu. ft. (air-dry) respectively. *Pyinkado* is the Burma species and irul the South India species. Both are excellent hardwoods for general utility work. *Pyinkado* is naturally very durable, and irul only slightly less so. They are both extremely strong tough woods, but are on the hard side for sawing and working unless green.

Bridges

Timbers for bridge construction must be *very strong* and *durable*, being subjected to great strains when heavy traffic passes over the bridge, and exposed to all kinds of weather. If the bridge surface is also wooden, the timber used must be *hard* and *able to stand up to continual wear and tear.*

The strongest and most durable timbers weight for weight in the above list are:—

	Weight (Teak = 100)	Strength as a beam (Teak = 100)	Stiffness as a beam (Teak = 100)
Acacia arabica	120	115	90
Anogeissus acuminata	125	115	120
Cedrus deodara	80	75	75
Dalbergia species	120	90	85
Dipterocarpus species	105	105	110
Hopea odorata	105	105	95
Mesua ferrea	135	140	145
Parashorea stellata	100	90	110
Pentacme suavis	130	120	125
Pterocarpus species	115	120	105
Shorea species	130	125	130
Terminalia tomentosa	120	100	100
Xylia dolabriformis	130	130	130

The percentage figures given above should not be taken as exact in cases where a number of species are included in one family, as for example in the case of *Dipterocarpus* species in which there are a large number of species of varying weights and strengths. The figures given are an average for all species tested in the family.

The hardest and most suitable timbers for bridge floorings include the following:—

	Hardness (Teak = 100)		Hardness (Teak = 100)
Acacia arabica .	180	*Pentacme suavis* ..	175
Albizzia species .	115	*Pterocarpus macrocarpus* ..	200
Anogeissus acuminata .	150	*Shorea* species ..	180
Dipterocarpus tuberculatus .	130	*Terminalia tomentosa* ..	130
Hopea species .	160	*Xylia* species ..	180
Mesua ferrea .	185		

Other superstructures

For other superstructural work such as derricks, scaffoldings, jetties, etc., all the timbers mentioned under 'Bridges' are excellent where great strength and durability are required, while most of those mentioned under 'Buildings' are also suitable except where durability is lacking (if durability is required). Non-durability can, however, be remedied by treating the timber with a good preservative such as coal-tar creosote or Ascu. It is preferable to treat and use timber in the round for such purposes, as round timber is stronger than squared timber and sapwood is more easy to treat than heartwood.

For Use in Contact with the Ground

In timbers for use in contact with the ground, the most essential feature is *durability*. Other necessary qualities will depend in each instance on the specific use to which the timber is to be put. The following are some of the most common examples of uses of woods in contact with the ground.

Railway sleepers

The replacements of wooden sleepers in the railway systems of India amount to about 4,000,000 sleepers a year. It will be realized, therefore, that the sleeper business is a very important item in the utilization of wood in India. During the past few years, the quantity of wooden sleepers used has fallen considerably. This is due largely to the introduction of the metal railway sleeper, which is now a serious rival to the wooden sleeper. At the present time, metal sleepers comprise

a little over 50 per cent of the total sleepers in Indian railway lines. The reason is not far to seek. The wooden sleeper in the past has been a comparatively expensive article, and it lasts only for 12 to 18 years according to the species and locality where laid. A metal sleeper, on the other hand, while costing very little more than a wooden sleeper, may last for 30 years or more under the same conditions. From a purely economic point of view, therefore, a metal sleeper has a distinct advantage over a wooden one. On the other hand, the question as to whether wood is preferable to metal for sleeper work is still undecided; the consensus of opinion being slightly in favour of wood. In Europe and America the consensus of opinion is definitely in favour of wood, but in India metal sleepers are favoured by a large number of railway engineers. Apart from the actual life of a sleeper, there are various other factors which affect the situation, the most important being the wear and tear on rolling stock, ease of running, ease of handling and laying, maintenance and renewals, and the importance of continuing support to an old-established forest industry. The wooden-sleeper industry cannot, however, expect to receive preferential treatment, and the Forest Department, realizing the seriousness of the situation, has taken steps to meet it. In the first place, the specifications of Indian railway sleepers are probably the most severe in the world, and the Indian railways have been somewhat spoilt in the past by being able to draw upon almost unlimited supplies of perfectly sawn and accurately dimensioned sleepers. In other countries, and especially in Europe and America, the sleepers accepted by railways are, on the whole, not nearly so good as the Indian product, and many shapes and sizes are used which would be rejected at once in this country, where a standard square-cut rectangular section sleeper only has been allowed in the past. The standard gauges of sleepers in India at present are as follows:—

Broad gauge $9' \times 10'' \times 5''$	Slight variations in *excess* of these sizes are accepted by all railways.
Metre gauge $6' \times 8'' \times 4\frac{1}{2}''$	
Narrow gauge $5' \times 6'' \times 4''$	

Specials—for use in crossings and bridges.

The sizes of 'specials' are specified at the time of purchase.

In 1929, the railways of India did, however, relax their former rigid specifications, and half-round and wane sleepers are now accepted, in some cases, subject to certain conditions.

In addition to the actual shape and dimension of a sleeper, the durability factor is of paramount importance. Here, fortunately, science can step in and help Nature by impregnation of the wood with preservatives. The impregnation of a wooden sleeper with a suitable preservative, such as coal-tar creosote or arsenic and copper solutions, increases considerably its life in the line. For

example, a chir pine sleeper will last untreated for about 2 years only, when laid in a line under the average conditions experienced in India, whereas the same sleeper, properly treated with a good preservative, may last from 14 to 16 years or more under similar conditions.

The preservative treatment of non-durable sleeper woods is, therefore, an important factor in timber utilization in a country like India, where conditions are usually favourable for termites and fungi.

Proper seasoning is another factor which has considerable influence on the life of wooden sleepers, and experience has shown that as a general rule (sal is a possible exception) a sleeper which is well-seasoned at the time of laying will outlast by several years a sleeper which has been laid in an unseasoned condition. This point has not been given the attention it deserved in the past, but of late years the proper seasoning of sleepers has been recognized as a vital factor in the life of railway sleepers in India.

Quality is also important, and there is little doubt that a sleeper of good quality wood cut from a large tree will outlast a poor quality sleeper cut from a small tree. The position in a sleeper of the heart centre of the tree has an important bearing on the life of the sleeper.

From the above brief discussion it will be seen that the successful competition of wood as opposed to metal, for use as railway sleepers in India, depends, in the main, on the following four conditions:—

(1) A low initial cost of the wooden sleeper.
(2) Relaxation of too rigid specifications.
(3) Preservative treatment for non-durable woods.
(4) Proper seasoning and good quality.

All four points have during the past few years been receiving the attention of the Forest and Railway authorities. The price of wooden sleepers has come down considerably, and yet the supply has been maintained. At the same time, the specifications of all kinds of sleepers have been reviewed, and in some cases relaxed. The specifications in most areas are, however, still on the severe side, and are far more rigid than European or American specifications. The specifications now in force can be seen in Appendix VII of this Manual. The introduction of half-round and wane sleepers might relieve the situation a little in certain localities, more especially in those districts where small-size trees abound, from which it is possible to cut say two half-round sleepers, whereas formerly it was possible to cut only one rectangular sleeper from the same tree.

Preservative treatment has also received its full meed of attention, and as the result of many years of research and trial the Indian railways are now treating about half a million sleepers *per annum*.

Seasoning has also been a burning question during the past few years and

several sleeper-seasoning experiments have been and are being carried out with a view to discovering the best method of stacking and seasoning sleepers of different species in various localities.

The woods most commonly used in India for untreated sleepers are sal (*Shorea robusta*) in Central and East India, deodar (*Cedrus deodara*) in Northern India, teak (*Tectona grandis*) in Central India, *Mesua ferrea, Xylia xylocarpa, Lagerstroemia parviflora*, and *Pterocarpus marsupium* in South India and *pyinkado* (*Xylia dolabriformis*) in Burma. In addition to these, *Hopea parviflora, Bischofia javanica, Shorea obtusa, Pentacme suavis*, and *Terminalia tomentosa* have also been used in fair quantities. Except for teak, sal, deodar, *pyinkado* and *Mesua ferrea*, none of the above woods are really naturally durable for long, and they do not last as sleepers for more than 10 years under normal conditions. They should, therefore, be subjected to preservative treatment before they are used for this purpose, since the railways expect a life of 15 years from their wooden sleepers in most districts.

As regards treated sleepers, chir (*Pinus longifolia*), blue pine (*Pinus excelsa*), spruce (*Picea morinda*), and fir (*Abies pindrow*) are the woods used by the North-Western Railway in their treating plant at Dhilwan on the Beas river. This plant can handle up to 800,000 sleepers yearly when working at full capacity. The North-Western Railway has in addition come to the conclusion that it is advantageous to give deodar a light treatment, and they are now treating a considerable number of deodar sleepers. This has enabled the Forest Department to supply deodar sleepers with a percentage of sapwood, since the treatment of sapwood renders it as durable as, if not more than, the naturally durable heartwood.

In Assam, *Terminalia myriocarpa, Cynometra polyandra, Eugenia jambolana, Altingia excelsa*, and *Dipterocarpus macrocarpus* have been used as treated sleepers, and in South India (Mysore) *Dipterocarpus indicus* and *Poeciloneuron indicum* form the bulk of the supply of the Mysore treating plant. Several species other than those already mentioned are quite suitable for use as treated sleepers, provided supplies are in sufficient quantities to warrant their introduction for this purpose.

In connexion with the utilization of various species for sleeper work, it should be noted that, although mature heartwood of such sleepers as sal (*Shorea robusta*) and deodar (*Cedrus deodara*) is naturally durable for many years, the sapwood of the same species is not. On the other hand, the sapwood of a timber like sal is easily treatable while the heartwood is not. This fact introduces the possibility of treating sleepers of sal containing a large percentage of sapwood (sapwood under existing specifications is strictly limited) and thereby rendering the sapwood of such sleepers as durable as the heartwood, and at the same time

utilizing that portion of the tree (the sapwood) which in the past has been cut away and left to rot in the forest.

The number of years that different woods will last in the line as sleepers depends on various factors, the most important of which are: (1) the situation where laid (whether dry or wet), (2) the kind of metalling used in the track, (3) the condition of the sleeper when laid (whether seasoned or green, sound, free from cracks, etc.), and (4) the amount of abrasion, rail-cut and spike-killing experienced. The following list gives the approximate life of the more common Indian woods when laid as sleepers in main lines under normal conditions:—

Treated		Untreated	
Shorea robusta (sapwood)	16–18 years	*Shorea robusta* ..	16–18 years
Cedrus deodara (sapwood)	14–16 years	*Xylia dolabriformis* ..	16–18 years
Pinus longifolia ..	14–16 years	*Cedrus deodara* ..	12–14 years
Pinus excelsa ..	14–16 years	*Mesua ferrea* ..	12–14 years
Terminalia spp. ..	14–16 years	*Xylia xylocarpa* ..	12–14 years
Picea morinda ..	12–14 years	*Pentacme suavis* ..	12–14 years
Abies pindrow ..	12–14 years	*Shorea obtusa* ..	12–14 years
Dipterocarpus spp. ..	12–14 years	*Hopea parviflora* ..	10–12 years
Shorea assamica ..	12–14 years	*Terminalia tomentosa* ..	Under 10 years
Anogeissus acuminata ..	12–14 years	*Bischofia javanica* ..	Under 10 years
Cynometra polyandra ..	12–14 years	*Lagerstroemia parviflora* ..	Under 10 years
Altingia excelsa ..	12–14 years	*Pterocarpus marsupium* ..	Under 10 years
Schima wallichii ..	10–12 years		
Lagerstroemia spp. ..	10–12 years		
Eugenia spp. ..	10–12 years		
Bischofia javanica ..	10–12 years		
Dichopsis elliptica ..	10–12 years		

Piles

Piles, the main upright members in bridge-building, etc., usually have the lower portion of their length sunk in the ground. This portion, and more especially that near the ground level on dry land, is very liable to attack by termites and fungi. The portion of a pile below water level is not liable to attack from termites or fungi. In addition, great strength is required, as all strains on the structure naturally fall on its main supporting members, and, as piles are usually driven into the ground, the wood used should be one that stands up to the continuous blows of the pile-driver.

The essential features of a good pile wood are, therefore, *great durability* (the most important), *great strength*, and *resistance to shearing and splitting and end crushing*. Amongst the best of the Indian woods for the purpose are the following:—

Acacia arabica (babul)
Acacia catechu (cutch)

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Artocarpus hirsuta (aini)
Cedrus deodara (deodar)
Hardwickia binata (anjan)
Heritiera minor (sundri)
Hopea parviflora (*thingan*)
Lagerstroemia lanceolata (benteak)
Mesua ferrea (mesua)
Shorea robusta (sal)
Tectona grandis (teak)
Xylia dolabriformis (*pyinkado*)

House posts

In the same way that piles form the main vertical members in bridge construction, etc., house posts are the chief support of buildings. House posts may be sunk into the ground or into the foundations of the building, or may be built into sills which rest on the foundations, so that the lower portion is often subject to termite and fungus attack. *Great durability* is, therefore, once again an essential feature for any wood used for this purpose, and as the posts are the main supporting members of the structure, *strength* is also essential. In addition, the timber should be *straight* and not liable to excessive warp.

All those species recommended for piles are suitable for the purpose, and, in addition, the following may be mentioned:—

Albizzia species (kokko, siris, etc.)
Anogeissus acuminata (yon)
Bischofia javanica (bishop wood)
Calophyllum wightianum (poon)
Cupressus torulosa (cypress)
Diospyros melanoxylon (ebony)
Dipterocarpus species (gurjun, *eng*, etc.)
Gmelina arborea (gamari)
Lagerstroemia species (jarul, etc.)
Ougeinia dalbergioides (sandan)
Pterocarpus species (padauk, bijasal, etc.)
Terminalia tomentosa (laurel)
Xylia xylocarpa (irul)

Although all the species mentioned in the above list are not naturally durable for more than a few years they can all be called reasonably durable woods. It is, however, always safer and more satisfactory to treat such woods with a good preservative, whenever possible.

Fence posts

For fence posts a *reasonably strong and durable* wood is required. The post one sees most commonly in India is a length cut from a young sapling or small tree, left in its natural round shape and often with the bark on. Such a post contains a very large percentage of sapwood, and as the sapwood of practically all species, including such woods as teak, sal, and deodar, is very liable to attack by fungi and insects, and as the bark on a dead stem is a certain attraction for wood-boring insects, a post of this type is not really serviceable. If the bark and sapwood are chipped off before the post is put in the ground, the result will be more satisfactory, and for temporary work, i.e. where posts are required for a year or two only, such posts will give good service if the species used has a reasonably durable heartwood. It may here be repeated that in most localities in India, the untreated sapwood of practically all species is attacked vigorously by termites, borers and fungi, within a few months of a post being put in position, and if a post is required to last for more than 6 months the wood used should either be cut from the heartwood of a fairly durable species or should be treated with a good preservative. As the portion of the post above ground is not so subject to attack by termites and is not so liable to rot as the portion under the ground or near the ground level, it is usually sufficient to treat only the lower portion of a post, provided the treatment extends for a foot or so above that part of the post which is level with the surface of the ground. A simple butt treatment in an open tank or barrel is usually all that is necessary and will suffice to prolong the life of the post considerably, but should the post be required to give service for a number of years, a thorough treatment in a pressure cylinder is necessary. A very useful and moderately durable post can also be obtained by charring the surface of the wood over a fire before placing the post in the ground. Some of the most naturally durable woods in India, and those most likely to give good service as fence posts, provided the heartwood only is used, are the following:—

Tectona grandis (teak)
Shorea robusta (sal)
Xylia dolabriformis (*pyinkado*)
Mesua ferrea (mesua)
Pentacme suavis (*ingyin*)
Shorea obtusa (*thitya*)
Xylia xylocarpa (irul)
Pterocarpus macrocarpus (Burma padauk)
Hopea parviflora (hopea)
Acacia arabica (babul)

Acacia catechu (cutch)
Heritiera minor (sundri)
Cedrus deodara (deodar)

Telegraph, telephone, and transmission poles

The most important requirement of a wood for poles for carrying overhead wires of a telegraph, telephone or electric current transmission system, is that it should be obtainable in *good long straight lengths.* At the same time it must be a *reasonably strong wood,* and if possible *durable.* As the durability factor is, however, applicable in a far greater degree to the butt end which is buried in the ground than to the rest of the pole, a butt treatment with a good preservative is commonly employed to give the necessary protection to this part of the pole. It is, of course, preferable if the whole pole is treated, as rot at the top of the pole, due to rain-water accumulating in cross-arm joints and penetrating into the open cracks which usually develop at the end of any log or pole, is apt to weaken this portion of the pole if no protection is given. Painting with coal-tar is often resorted to, in order to protect the tops of poles. This is effective, inasmuch as the tar fills up all cracks already developed, but coal-tar is not a very toxic substance, and if new cracks start, rot would soon develop inside the coating of tar. The most suitable species for untreated poles can easily be selected from the lists of durable species given in the previous pages, always remembering that good straight lengths up to about 36′ are essential, although the majority of the poles used for electrical transmission work do not often exceed 35′. Amongst the best for the purpose are *Shorea robusta, Tectona grandis, Cedrus deodara, Xylia dolabriformis,* and *Artocarpus hirsuta,* while for treated poles any straight-growing species is suitable provided it has the requisite strength. Chir pine and sal have both been used for the purpose, the former making an excellent straight pole. If untreated poles are used, it must not be forgotten that all the perishable sapwood must be trimmed off.

Mine props

There is a steady demand in India for suitable timbers for pit-props in coal mines and for shoring and facing exposed surfaces of loose earth in underground workings. As the timber is exposed to the still damp air of the mines and is usually in direct contact with the ground, *durability* is again an essential factor, but at the same time *resistance to compression parallel to the grain, and strength and stiffness in bending* are important features in the case of pit-props, as they have to withstand the enormous pressure exerted by the weight of earth they support. The results of this steady downward pressure can be seen from the indentations made by the top of the props in the head-blocks, which are square

pieces of timber 3 or 4 inches thick placed between the earth and the top of the prop to give a larger supporting surface than the top of a prop affords. In some cases the pit-props are almost forced through these head-blocks, especially if the latter are of soft wood.

Pit props are usually employed in the round in lengths of 6 to 12 feet, and amongst the best species for the purpose are such timbers as *Tectona grandis*, *Shorea robusta*, *Xylia dolabriformis*, and *Heritiera minor*. Other woods used are *Terminalia tomentosa*, *Diospyros melanoxylon*, *Anogeissus latifolia*, and *Hopea parviflora*, while *Gmelina arborea* has been reported on as making an excellent pit-prop, and is said to be as durable as teak. It is, however, not too plentiful, especially in Burma, where *Anisoptera glabra* is considered as a possible substitute.

In conclusion, the value of preservative treatment must again be emphasized in the case of pit-props and other mine timbers. Such treatment not only provides a very much larger list from which a selection can be made, as all fairly strong non-durable woods can be included, but also provides additional protection to the sapwood in the case of such timbers as are durable in the heartwood but are usually used in the round, which means employing a large quantity of otherwise perishable sapwood. In this connexion it is interesting to note that a 15-year-old sapling of sal contains no less than 60 per cent of sapwood. Anyone using a round untreated pit-prop, fence post or telegraph pole of sal or any other species, therefore, while fondly imagining that he is using durable wood, is in reality using a small core of durable heartwood, not much larger than a thick stick, surrounded by a 2- or 3-inch covering of quickly perishable sapwood. Up to about 6 or 7 years old, most saplings contain no heartwood at all, and the importance of realizing the great difference between the durability of heartwood and sapwood cannot, therefore, be over-estimated. The durability ratio between heartwood and sapwood is often as much as 12 : 1, or, in other words, while the heartwood lasts for 12 years, the sapwood is completely destroyed in less than a year.

Paving-blocks

The use of wood for road surfaces, in the form of small blocks imbedded in bituminous compounds, has grown considerably during the past decade, and in large cities where traffic is exceptionally heavy, wooden paving-blocks still hold pride of place for street surfacing. It might be imagined in these modern days of reinforced concrete and other compositions, that wood might be supplanted for road-surface work, but the truth of the matter is that wood has certain qualifications as a street surfacing material, which none of the substitutes, so far discovered, possesses. In the first place, wooden paving-blocks compare favourably in cost with other surfacing materials, and offer a better

resistance to the skidding of motor-cars than concrete or composition surfaces. In addition wood blocks have been found to compare very favourably in durability and wear and tear with other street surfacing materials; but above all they are silent under heavy traffic, which in streets fronted with offices and shops is an important consideration. No material has yet been found to last for more than a few years under exceptionally heavy city traffic, and as wood-paved streets are in the end as cheap as other road surfacing materials, although comparatively expensive in the first place, they often find favour in the eyes of road engineers on the score of silence, resilience and economy, when streets have to be resurfaced in any case every few years. In London, for example, wood-paved streets are being laid more extensively than ever, but in America engineers are still inclined to keep to concrete and cement. It must, however, be clearly understood that the above remarks refer in the main to *street* paving and not in general to road paving in country districts, where other materials are usually preferred to wood.

The chief requisites of a good paving-block of wood are *durability, resistance to wear and tear, resilience and non-liability to absorb water excessively.* The texture should also be even, otherwise the blocks wear unevenly. Blocks may vary in size, the maximum being about $10'' \times 6'' \times 4''$, but the blocks for any piece of work should be of uniform quality, to avoid uneven wear. The general rule is that all road or street surface paving-blocks are laid with the cross-section surfaces at top and bottom and not at the sides. This is necessary to procure even wear and tear, the end-surface of wood wearing far more evenly than the tangential or radial surfaces.

Amongst the woods so far tried in India for street paving-blocks, *Xylia dolabriformis* and *Tectona grandis* have been proved excellent. *Xylia dolabriformis* blocks laid in the streets of Bombay and Rangoon lasted 20 years. *Hardwickia binata* has also been tested and found good.

Other timbers which would probably be suitable are *Acacia arabica*, *Acacia catechu*, *Hopea parviflora*, *Mesua ferrea*, and *Pterocarpus macrocarpus*, but, generally speaking, and with few exceptions, street paving-blocks should be treated. In England creosoted *Pinus silvestris* (red deal) and *Pseudostuga taxifolia* (Douglas fir) are the most common woods used for the purpose, while *jarrah* and *karri* from Australia are also employed to a lesser degree.

Timber slides and corded roads.—Timber slides are usually constructed of logs or poles, sleepers, or more rarely, planks. The slides may be dry or wet and may be of a temporary or permanent nature. For temporary slides, either wet or dry, almost any timber obtainable in the vicinity will suffice, but when a slide is to remain in position for a number of years a durable wood is essential if continual repairs, due to rot, are to be avoided. The wood in most

common use in the Northern Himalayas is deodar, which lasts for many years in mountain districts. In Burma, teak and *pyinkado* are used, and in the Sunderbans of Bengal *Heritiera minor* is employed for slipways and corded tracks on the soft mud river banks. In other localities, saplings of any wood found in the vicinity are usually used.

For Use in Contact with Water

The uses of wood in contact with water may be divided into the following classes:—

(1) Marine work.

(2) Fresh water work.

(*a*) When the wood is submerged,

(*b*) When the wood is exposed to alternate wetting and drying.

Each class of work calls for special and necessary features in the wood to be used. In marine work, damage from marine borers is by far the most serious consideration, while a wood to be used under water and kept submerged requires different qualities to a wood which is to be exposed to alternate wetting and drying. If a wood is really kept completely and continually submerged in fresh water it should in theory last for ever, as no deterioration can take place under water.

Marine piles

For the piles of piers, jetties, bridges, etc., in salt or brackish water, a wood permanently resistant to the attack of *Teredo navalis* and other marine borers is required. Such a wood has not yet been found, and anyone who can discover a teredo-proof timber would receive the undying gratitude of the civilized world.

Descriptions of such timbers as greenheart (*Nectandra* species) from the West Indies, and *jarrah* (*Eucalyptus marginata*) from Australia, are often found to contain the statement that these timbers are immune to attack by marine borers. This is definitely not so and these timbers are no more free from perpetual attack by some species of marine borers than many other durable Indian woods such as teak and *pyinkado*. The fact of the matter is that there are many different species of marine borers in different parts of the world, and although it is possible that certain species may remain immune for a number of years in one locality, they may still be vigorously attacked in another. Exhaustive tests have been conducted to determine the degree of immunity of different materials in different parts of the world, and except for certain timbers remaining intact for a few years in some localities, there is an increasing mass of evidence to discount the complete immunity of any species of timber in all countries and under all conditions. On the other hand, the value of a preservative

treatment with coal-tar creosote as a protection against teredo has been well established, and anyone wishing to get value for money in constructing piers and jetties in teredo-infested waters would be well-advised to use pressure-treated timber with coal-tar creosote as the preservative. If preservative treatment under pressure is not possible, then open tank treatment should be resorted to, and provided there is good penetration of the creosote for at least $\frac{3}{4}''$ to $1''$, the life of the timber should be increased by several years. If no preservative treatment of any kind is possible then the only thing to do is to use the most durable timber available, but even the best of these are often destroyed in a short while, if marine borers are prevalent.

The most durable Indian woods in this respect are teak, *pyinkado* (*Xylia dolabriformis*), sundri (*Heritiera minor*), Burma padauk (*Pterocarpus macrocarpus*), and *Stereospermum* species, but none of these last so well as creosoted hardwoods. *Dipterocarpus turbinatus* (gurjun) has done exceptionally well in Burma when creosoted, while untreated *Artocarpus gomeziana* has the reputation of being immune to teredo attack in the Andamans. Well treated Ascu-preserved wood has also done well in some Indian harbours.

Fresh water piles

As marine borers, and especially *Teredo navalis*, are confined to brackish and saline water, constructional work in fresh water is not subject to attack by these pests, and the selection of timbers for this type of work is thereby greatly simplified. On the other hand, the type of work for which the timber is required plays an important part in selecting the best wood for any specific purpose. If the structure is to be completely immersed in fresh water at all times, selection is easy, as submerged wood is protected from attack by insects and ordinary fungi, and several woods which are considered as most perishable when exposed to the air, give good service indefinitely if kept under water. Good examples of this are *Bombax malabaricum, Boswellia serrata, Erythrina suberosa, Mangifera indica,* and *Terminalia belerica.* All these woods are perishable timbers in ordinary circumstances, but if kept completely submerged under fresh water they remain almost indefinitely in good condition. If, on the other hand, the structure is to be exposed to alternate wetting and drying, the situation is entirely changed, as conditions most favourable to the rapid development of wood-destroying fungi are at once set up. Unfortunately, in such constructions as piers, jetties, bridge piles, well curbs, sluice gates, and river bank protection against erosion, alternate wetting and drying is unavoidable, and it is necessary to use only durable timbers for this type of work, unless preservative treatment is adopted. The choice is, therefore, once again restricted to such woods as *Acacia arabica, Artocarpus* species, *Bischofia javanica, Cedrus deodara, Hardwickia binata, Heritiera minor,*

Hopea species, *Lagerstroemia* species, *Mesua ferrea*, *Shorea* species (except *Shorea assamica*), *Tectona grandis*, and *Xylia dolabriformis*. Of these, *Bischofia javanica*, and *Lagerstroemia hypoleuca* (jarul) have been reported on as being exceptionally durable if kept wet, and the latter timber has lasted extremely well in jetties and pier piles in the Andaman Islands. *Bombax malabaricum* has also been used with complete success for sectional wooden stave water conduits. *Xylia dolabriformis* has been reported on as the best of all Indian timbers for water work in fresh water or above salt-water level in rivers.

Ship- and Boat-building

General

In former years, before the advent of iron and steel, the demand for ship-building timbers was one of the heaviest on the timber industry. In present times, the demand is still very large, but the purposes for which the timber is required have changed. In the days of large sailing vessels the whole structure of a ship was of wood, from keel to mast-top. Nowadays, it is the rarest thing to see a ship of more than a few tons burden constructed of wood. Iron and steel have swept all before them in the sphere of ship-building, and in the large ocean steamers of today, wood is confined chiefly to deck planking and interior fitments. This, of course, is only natural when it is remembered that iron ships are stronger and more able to resist the buffetings of heavy seas, are more durable and easier to repair, and can be built to sizes far beyond the possibilities of wood.

At the same time, it must not be imagined that the demand for wood in the ship- and boat-building trade has fallen. It has in fact increased, but, as stated above, the uses to which the timber is put have changed. The shipping of today is many times what it was years ago, and the demand for deck planking, cabin fitments, and interior decorative woods is greater than ever. For example, over 1,000 tons of teak were used in the construction of the *Queen Mary* alone, in addition to numerous other woods. In addition, the number of smaller craft such as pleasure boats, fishing smacks, racing yachts, river craft, and motor launches has increased considerably in the past thirty years, and wood still holds pride of place in the construction of this type of craft. In India, there always has been, and always will be, a steady demand on the sea coasts and large rivers for indigenous boat-building woods for the construction of local craft. The timbers used are usually local woods which have been tested through the centuries and proved satisfactory by continued use. Before discussing these local woods, a few words must be said concerning teak. Teak is in a class by itself so far as ship-building is concerned. It is the best ship-building timber in the world, chiefly on account of its durability, strength, and freedom from warping and 'movement' due to its low shrinkage value. It is used extensively

by all Admiralties for naval work, and the best teak squares from Burma are known as Admiralty teak and are exported to England for the use of the Navy, and other Government departments.

Next to teak, oak wood (*Quercus* spp.) is the most used ship-building timber in the western hemisphere. It is very strong and durable, but has a bad reputation for corroding iron owing to the tannic acid it contains. As a matter of fact, teak also corrodes iron to some extent, although it has a reputation for not doing so, but this defect is not serious in these days of yellow metal and galvanized fastenings.

Beyond teak and oak, which probably comprise two-thirds of the timber used in Europe for ship-building, there are few other woods of importance used in Europe. Ash (*Fraxinus* species) is used for certain purposes such as oars and ships' derricks, beech (*Fagus* species), birch (*Betula* species), and maple (*Acer* species) are employed in interior fittings, and mahoganies (*Swietenia* and *Khaya* species) are in demand for decorative work and furnishings. Mahogany is also much used for small boat-building, and is one of the best woods on the market for polished side planking in pleasure boats, punts, and motor launches.

In India, as already mentioned, the demand for boat-building woods is mainly local, although teak is in constant demand in the larger ship-building yards. The following lists include most of the chief boat-building woods of the country:—

Hulls (excluding dugouts)

For the hulls of coastal and river craft, *durability*, *strength*, and *freedom from defects* are essential qualifications for the timber used. The most usual type of boat consists of a framework of curved pieces known as knees and ribs, which are let into a straight piece of wood running the entire length of the boat and called the keel. This framework forms the skeleton upon which the outer planking is fixed. Details of construction vary considerably in different localities and for different purposes. For sea-going boats, great strength is essential, while for river craft, strength is not such a necessary feature, and the knees or ribs can be further apart and the keel not so heavy. In some flat-bottomed types of boat there is no keel. The following timbers are amongst the best for general boat-building purposes in India:—

Acacia arabica.—Much used in North and West India (from Bombay northwards) for all parts of boats. Being hard and strong, it is a good keel wood.

Artocarpus hirsuta.—One of the most valued of woods for boat-building in South India. It is very durable and steady.

Calophyllum species.—Common boat-building timbers of the south coasts. *Calophyllum inophyllum* is especially popular, its natural resin probably acting as a preservative.

Dalbergia latifolia.—Being strong, elastic, and tough, rosewood and its sister species *Dalbergia sissoo* (sissoo) are popular in the districts where they occur for frames, knees, and ribs.

Dipterocarpus turbinatus.—Commonly used in Burma and Chittagong. Here again, the natural oleo-resin of gurjun probably acts as a preservative of the wood.

Heritiera minor.—The chief boat-building timber in the Sunderbans of Bengal and in Calcutta. Three-quarters of the country boats used on the Hooghly are made of sundri wood.

Hopea parviflora.—A favourite boat-building timber in Travancore.

Lagerstroemia species.—Several species of *Lagerstroemia* are popular for boat-building, *Lagerstroemia lanceolata* being one of the chief shipwright woods of the West Coast.

Pterocarpus dalbergioides.—Being strong, tough, elastic, and durable, Andaman padauk is a first class boat-building wood. *Pterocarpus macrocarpus*, being exceptionally hard, makes an excellent keel wood. It is also used in Burma for frames of lifeboats, and is considered superior to teak for the purpose.

Thespesia populnea is reputed to be good for ribs and knees in Madras.

Xylia dolabriformis.—A popular timber for sea-going boats in Burma. It is hard and very durable and is an excellent keel and stem- and stern-post wood.

Many other woods are used in India for boat-building, but to give a lengthier list would merely be confusing. The above timbers are representative of the best and will suffice as an indication of the types of wood required for the purpose.

Deck planking, outer planking, linings, etc.

For the outer planking of boats, any good sound timber will suffice, provided it is free from defects, and is not liable to excessive splitting or cracking. Long lengths are desirable, and timbers with small shrinkage figures are preferable to those which are liable to swell and contract with changes of humidity and temperature. In Europe, mahoganies and walnuts are popular for the highest class of motor launches and pleasure boats, and mahoganies are used almost exclusively for river punts, while Canadian canoes are usually covered with

thin strips of cedar or pine. In the case of fishing boats and rougher craft, oak, ash, and pine are used for the outer casings, and the boats are often heavily tarred to keep them waterproof and in good condition. In South India fish oil and some wood oils are used for preserving boats.

Amongst Indian timbers, *Adina cordifolia, Cedrus deodara, Pentace burmanica, Gmelina arborea,* and *Mangifera indica* have been used with success in addition to the species mentioned above as suitable for hull work.

Masts and spars

Timber for masts and spars must be obtainable in long straight lengths, and must, in addition, be sound, strong, and elastic, and not too heavy.

In Europe, slow grown coniferous woods are used almost exclusively for this purpose, spruce (*Picea* spp.), larch (*Larix* spp.), and especially pine (*Pinus* spp.) being in most demand. In India, the well-known poon spars from *Calophyllum* species have a well-deserved reputation. These spars are obtainable in clean straight pieces up to 30′ or more in length. Such large masts are not, however, as much in demand nowadays as they were in the days of big sailing vessels, and for the smaller masts of coastal and river boats there are many other suitable species. *Cedrus deodara* is most commonly used in the north of India, and *Casuarina equisetifolia* and *Lagerstroemia lanceolata* on the Bombay side. In Bengal, *Heritiera minor* from the Sunderbans, and *Podocarpus neriifolia, Sageraea elliptica,* and *Calophyllum spectabile* from the Andamans are popular, while Burma has a plentiful supply of suitable spar woods in *Tectona grandis, Homalium tomentosum,* and *Lagerstroemia flos-reginae.*

Large bamboos are also commonly used in India for mast and spar work; in fact in the smaller country river-boats, bamboo masts are seen more often than wooden ones.

Oars and helms

For oars and helms, a *straight-grained, strong, elastic,* and *preferably light* wood is required. In any case, the wood should be one that floats in water, otherwise loss due to sinking would cause considerable inconvenience. Most of those woods used for masts, spars, knees, and ribs are suitable for oars and helms so long as clean, straight-grained wood is used. *Grewia* species may also be mentioned in this connexion as it is a very strong tough wood, well-adapted for such uses. A bad knot in an oar is obviously a defect, and similarly short-fibred wood with the direction of the grain at an angle to the length of the oar would soon result in the oar breaking if a heavy strain was put upon it. In the case of helms also, there is very considerable strain, and clean straight-grain is important, always remembering that the safety of the boat may depend on the

helm. A specially good wood for such purposes and one tested and found most serviceable by Port Trust officials is *Podocarpus wallichianus* (thitmin) from Burma. It has also proved to be a first class boat-hook wood.

Keels, stern- and stem-posts

Most of the timbers mentioned as suitable for the framework of hulls are suitable also for keels, provided they are *hard* woods and obtainable in straight pieces of the required length. In the same way, stem- and stern-posts are continually getting bumped and banged against rocks and masonry piers, and require to be *hard* and *tough*. Such woods as *Acacia arabica, Heritiera minor, Hopea parviflora, Mesua ferrea, Pterocarpus macrocarpus,* and *Xylia dolabriformis* are good timbers for such purposes.

Dugouts

Dugouts are made by hollowing out a single log in the form of a boat or canoe, either by slowly chipping out the core of the log with an axe, or by burning it out with fire. The most important feature in selecting a species for dugouts is its *non-liability to splitting and cracking*. Many species are used for the purpose, and the selection of a good sound straight log is often more important than the species itself, provided always that the wood is not a bad splitter.

Duabanga sonneratioides is an excellent wood for dugouts, and *Berrya ammonilla*, a very tough wood, is often used in Burma and South India. *Palmyra* is also commonly used for this purpose in Madras. *Mangifera indica, Bombax malabaricum*, and *Tetrameles nudiflora* are popular in some parts of India, *Bombax* being extremely light, and therefore easy to handle, and, at the same time, being durable if the wood is kept wet. All three species are readily attacked by fungus if not kept wet, and dugouts made from them should be kept submerged in water if possible when not in use. When used for dugouts they are often rubbed with fish oil, and then they last 10 years or more.

Rafts and life-saving apparatus

All large ocean-going vessels and boats carrying passengers are compelled to carry sufficient rafts and life-saving apparatus to accommodate everyone on board. These rafts are usually made of some very light buoyant wood. The wood most in demand for this purpose is balsa (*Ochroma* species), a very light tropical American wood weighing only 8–10 lb. per cu. ft. Some specimens of this wood have been recorded as weighing only 4 lb. per cu. ft. The weight of commercial cork is 11–13 lb. per cu. ft.

The supply of this wood is, however, limited, and bakota (*Endospermum malaccense*) from the Andaman Islands is increasing in popularity as a substitute.

The British Admiralty have used bakota, which is known in Europe as Indian balsa, as a substitute for the true balsa wood. It is somewhat heavier than true balsa but is still a very light buoyant wood and does not absorb water quite so readily as *Ochroma lagopus* which forms the main supply of balsa wood. Semul (*Bombax malabaricum*) is also used to a lesser degree for the same purpose, but the weight of semul is about 23 lb. per cu. ft.

Joinery and Cabinet-making

Joinery

By joinery is usually meant the work of an ordinary carpenter. This work comprises all the interior fitments of houses and other buildings, such as windows, doors, staircases, cupboards, plain furniture, and the thousand and one other articles which are part and parcel of our daily lives.

Timbers suitable for this work are many, and provided a wood is available at a moderate price, is easy to work, and has no great drawbacks, it will be used for joinery work. Most localities in India have such woods in the neighbouring forests, and the selection, as stated above, is more a question of availability than of true suitability.

In Europe and America, the coniferous woods known as 'deal' are used for three-quarters of the joinery work of those continents. In fact the softwood forests of Canada, the United States and Europe supply 80 per cent of the world's timber, and the United Kingdom alone imports softwood timber to the immense value of £37,000,000 per annum.

In India, true softwoods (conifers) are not easily or cheaply available to the whole country. They are confined in the main to the Himalaya ranges, and their use is restricted to those areas where they can be put on the markets at economic prices. The chief timbers of this description are *Cedrus deodara* (deodar), *Pinus longifolia* (chir), *Pinus excelsa* (blue pine), *Picea morinda* (spruce), *Abies pindrow* (fir), and *Pinus khasya* (*khasya* pine). They are all good joinery woods, being easy to work, available in fair quantities in the areas where they grow and at moderate prices. In other parts of India the position is different. In South India, for example, there are no indigenous conifer woods in quantity, and the joiner has to be content with hardwoods. Those in most demand are such common woods as *Artocarpus* species, *Bassia latifolia*, *Dysoxylum malabaricum*, *Hopea parviflora*, *Lagerstroemia flos-reginae*, *Lagerstroemia lanceolata*, *Lagerstroemia parviflora*, *Mesua ferrea*, *Pterocarpus marsupium*, *Terminalia paniculata*, and *Terminalia tomentosa*.

In the United Provinces, *Cedrela toona*, *Dalbergia sissoo*, and *Shorea robusta* are the three most commonly used woods, while *Adina cordifolia*, *Acacia arabica*,

Eugenia jambolana, and *Bombax malabaricum* are often to be seen in joiners' shops.

In Bengal and Assam, there are numerous hardwoods suitable for the purpose. *Shorea robusta, Heritiera minor, Dipterocarpus macrocarpus, Terminalia myriocarpa, Cedrela toona, Michelia* species, and *Mesua ferrea* being amongst the most common.

In Burma, teak is naturally used more than any other wood for joinery purposes, but *Dipterocarpus turbinatus, Dipterocarpus tuberculatus, Pterocarpus macrocarpus, Terminalia tomentosa, Hopea odorata, Parashorea stellata*, and *Xylia dolabriformis* are yearly coming into greater demand. It will be seen, therefore, that there is a large selection of joinery woods in most parts of India, and local carpenters are usually well aware of the timbers which suit their requirements best.

Cabinet-making

For high class work of an expensive nature, a better quality wood is required than that usually employed for ordinary joinery work. Cabinet-making comprises all the finer works of carpentry such as the making of pianos, writing desks, bookcases, billiard tables, dining tables, sideboards, screens and the other articles of furniture usually found in well-to-do residences, offices and elsewhere. As the work is skilled and the price of the finished article is comparatively high, only the finest timbers are required for this work. The chief requisites are *good colour, handsome 'grain' or 'figure', and non-liability to crack, warp, or 'move' excessively.*

India possesses many fine cabinet woods, and such timbers as teak (*Tectona grandis*), Indian rosewood (*Dalbergia latifolia*), padauk (*Pterocarpus dalbergioides*), East Indian satinwood (*Chloroxylon swietenia*), ebony (*Diospyros* species), and walnut (*Juglans regia*) have been known for centuries in European markets. There are, however, many other timbers in India which are not so well known, but which, nevertheless, are extremely fine cabinet woods. Amongst these, the following are worthy of notice:—

Albizzia species ..	Good colour. Handsome grain. Very steady and reliable.
Artocarpus species ..	Often ornamental, and very steady woods.
Calophyllum species ..	Excellent for panellings. Obtainable in large sizes.
Cedrela toona ..	An inexpensive substitute for mahogany. Much used throughout India and Burma.
Chukrasia tabularis ..	Can be very ornamental. Easy to work and fairly steady.

Dalbergia species	..	Fine handsome cabinet woods of very good repute.
Gluta species	..	Carves well and finishes cleanly.
Pterocarpus species	..	Excellent furniture woods. Very strong and steady.
Terminalia species	..	Variable but can be extremely handsome, e.g. laurel and silvergrey wood.
Carapa moluccensis	..	A very sound cabinet wood of good colour and texture.
Melanorrhoea usitata	..	A fine furniture wood not unlike mahogany.
Millettia pendula	..	Usually has a fine 'partridge' figure. Hard and heavy but finishes very cleanly.

Chairs and camp furniture

A chair wood must be *strong, elastic, and tough* to stand the great strain put upon it when the chair is tilted. Lightness is desirable if it can be obtained without impairing the above qualities.

In Europe, bentwood chairs are in common use. These chairs are usually made of beech (*Fagus* species), which is steam-bent and then dried off in a permanently bent form. In India, up to the present time, very little steam-bending is done, and chair parts are usually cut from the solid timber.

The best and most commonly used chair wood in North India is sissoo (*Dalbergia sissoo*). In Burma and the rest of India, teak is largely used, while *Acrocarpus fraxinifolius, Artocarpus chaplasha, Calophyllum* species, *Chukrasia tabularis, Dalbergia latifolia, Gmelina arborea, Juglans regia, Lagerstroemia* species, *Ougeinia dalbergioides, Pterocarpus* species, and *Terminalia bialata* are all suitable.

For camp furniture (other than beds), *lightness* is a consideration, and *Phoebe hainesiana* is a wood which is worthy of notice in this connexion. It is a very light but reasonably strong wood and exceptionally free from splitting, cracking, and warping. White cedar (*Dysoxylum malabaricum*) is also an excellent wood for camp furniture and is very popular for this purpose in South India. Supplies are, however, limited, and *Zanthoxylum rhetsa* has been found to be an excellent substitute. *Hardwickia pinnata* is also good and much used in Madras for camp cots. Imported camp furniture is usually made of ash or beech, and in India sissoo (*Dalbergia sissoo*) is largely used, especially for camp beds, *where strength is a necessity*. In the Punjab, horse chestnut (*Aesculus* sp.) from Kashmir is very popular for camp furniture.

Veneers and plywood

Veneers are thin sheets of wood peeled, sawed, or sliced from a log and used as ornamental overlays on a cheap wood background. They may vary in thick-

ness from $\frac{1}{64}''$ to $\frac{1}{4}''$ or more, and are chiefly employed as a means of economy. A typical example of this form of woodwork is the well-known walnut burr veneer furniture of America and Europe. In this instance, the burrs, which contain some extremely handsome curl wood, are sliced into thin sheets, which are in turn matched up to form decorative designs and patterns, and are then glued on to some inexpensive wood background. The final result is a decorative board of extremely fine appearance and costing considerably less than a solid board of the figured burr wood. Only the most highly figured and costly woods are used for veneer work, and in India the trade is as yet hardly known. In former years, there was a good export business in walnut burrs from North India, and as much as two thousand rupees was paid for a really first-quality burr. The trade died a natural death, however, some years ago, due to the available supplies of burrs having become exhausted, and at the present time there is only a very small export business of veneer woods from India.

This does not, however, mean that India does not possess woods which are suitable for high class veneer work. On the contrary, some of her timbers are of extreme elegance, and when they become better known will no doubt be in good demand.

At present there is no factory in India which cuts high grade figured veneers, but there is little doubt that the time will come when the business will be a thriving one.[1]

Amongst the finest timbers for ornamental veneers in India, the following are of approved merit:—

Tectona grandis (especially Central Indian teak)
Dalbergia sissoo
Chukrasia tabularis
Pterocarpus dalbergioides (preferably sawn or sliced)
Dalbergia latifolia
Dalbergia oliveri
Dalbergia cultrata
Swietenia macrophylla
Terminalia tomentosa (for sawn or sliced veneers only)
Terminalia bialata (for sawn or sliced veneers only)
Cedrela toona

Closely connected with ornamental veneer work is the plywood industry. Plywood is made by gluing three or more veneers together with the grain of successive plies at right angles to each other. Plywood is usually made in the form of 3, 5, 7 or 9 plywood, an odd number of plies being generally necessary to keep a proper balance, and to eliminate any tendency to warp which might arise if

[1] Since this was written, two veneer slicing factories have been started in India, one in Calcutta and the other at Sitapur in the United Provinces.

there were not an equal number of plies on each side of the centre ply or core. Plywood manufacture has been in existence for some years in India.

As a rule, plywood is made from veneers cut on a rotary lathe. In this form of veneer, the plies are peeled off the log by rotating it against a sharp knife, with the result that a long continuous sheet is 'unrolled' from the log, similar to the unrolling of a roll of carpet. The long sheets are then cut into short lengths and glued together as plywood. Most plywood is made up with a solid core of veneer and veneered faces, but sometimes a laminated core is used. This last form of manufacture is especially suited to Indian conditions as cracking and splitting and 'movement' are reduced to a minimum.

In general, however, when talking of plywood, the well-known 3-plywood is referred to, and it is this product which is most universally used, not only for tea boxes and similar containers, but for all manner of articles such as cabin trunks, suit cases, drawer bottoms, dust boards, door panels, aeroplane fuselage covers, and many other commodities.

There are only two plywood mills in India at present.[1] Both are in Assam and both use the same woods, namely hollong (*Dipterocarpus macrocarpus*), hollock (*Terminalia myriocarpa*), toon (*Cedrela toona*), semul (*Bombax malabaricum*), and chickrassy (*Chukrasia tabularis*), the first two forming the main supply of their requirements, which are in the main confined to tea box work The great advantage that plywood has over solid wood is its lightness combined with increased strength, a normal plywood board being three times as strong as a solid board of the same thickness. In addition, plywood can be made available in very large sizes which are quite impossible with solid wood. It is also very easy to work, and it can be bent to shapes of unlimited design.

Parquetting

Wooden floors are the exception rather than the rule in India, due chiefly to the ravages of insects and more especially termites. A wooden floor is, nevertheless, very much more pleasant than the usual cement and concrete floor so commonly found in Indian houses, and there are several Indian woods which are suitable for the purpose. The chief requisites of a good floor wood, whether to be used in the form of strips or parquet blocks, are *hardness* to withstand wear and tear, *durability*, and *non-liability to excessive swelling, shrinking and warping* with changes in atmospheric moisture and temperature.

One of the best woods for the purpose is *Pterocarpus macrocarpus* (Burma padauk). This wood is twice as hard as teak and is an exceptionally durable and 'steady' wood, which when laid in the form of parquet blocks makes a very handsome floor. *Pterocarpus dalbergioides* would also make an excellent parquet

[1] Since this was written, a third plywood mill has started manufacture at Kallai in South India. The woods used are semul, mango, *Vateria indica*, and rosewood.

floor. Other good floor woods of proved utility are *Tectona grandis*, *Dipterocarpus turbinatus*, *Hardwickia binata*, *Hopea parviflora*, *Xylia* species, *Albizzia lebbek*, and *Lagerstroemia flos-reginae*. Teak is already largely used in India for flooring and is an excellent wood for the purpose on account of its extreme steadiness. Parquet floors are usually laid with the longitudinal surface of the wood uppermost. Blocks may vary in size, but as a general principle it can be stated that small blocks give better satisfaction than large blocks, due to the smaller shrinkage of individual blocks, thereby lessening the gaps which often appear between the blocks in floors.

Vehicle Parts

Railway carriages and wagons

The railways are the best customers of the Forest Department in so far as the purchase of timber for carriage and wagon building is concerned. In 1929-30, 45,000 tons of indigenous wood were taken by the railways of India for use in their carriage and wagon shops. Out of this total, 31,000 tons were teak and 14,000 tons were other indigenous timbers. In 1930-31 the figure for other indigenous timbers had risen to 50 per cent of the total timber used.

A few years ago the purchases of indigenous timbers other than teak were considerably lower even than for 1929-30, and the figures of 1930-31 are a good indication that the railways realize that teak is not the only wood suitable for carriage and wagon work. That teak is an excellent timber for the purpose there is no gainsaying, and the records of the life of some of the carriages on the Indian railways fully endorse this, but in such instances as repairs to a carriage which in any case is only going to be kept running for a few years longer, or where flooring is required for goods wagons, it is obviously uneconomical and altogether unnecessary to use an expensive timber like teak. The chief requisites of a good railway carriage and wagon timber are that it shall be sufficiently *strong* for the purpose for which it is to be used, that it shall be reasonably *free from bad seasoning defects*, and that it shall be *available in sufficient quantities* to ensure a continuous supply of not less than about 500 tons per annum.

The last point is important and one on which the railways lay great stress. Railway workshops are like large factories, where a continuous output is necessary for economic working. This output can only be maintained if supplies are continuous, and well-balanced. The introduction of a number of different species in small quantities immediately upsets this balance, and as the railways do not like carrying large stocks, all timber passing through their shops must be used up as soon as possible. If several species in small quantities are coming through mixed indiscriminately with teak, and are used mixed with teak in the same piece of work, a patchwork construction results which would soon be discarded as

unsatisfactory. The remedy lies in using those timbers of which a continued supply is assured, and using them only for specific parts of a carriage or wagon. For example, a certain timber has been passed as suitable for floor boards. This timber when received by the railway workshops can be converted into floor board sizes and used exclusively for that purpose, the usual output of teak floor boards being reduced accordingly.

The chief difficulty in furthering the use of indigenous woods other than teak for railway carriage work is the vital question of seasoning. Burma teak, having stood girdled in the forest for two or more years, and then having been floated down rivers to the export depots—a proceeding which may occupy a number of years—arrives at the railway workshops in India in a partially dry state, and is usually converted and used up without further seasoning. On the whole, the results are satisfactory, teak being a paragon amongst woods in this respect: having a very low coefficient of expansion and contraction, it stands up in a surprising manner to the capricious changes of the Indian climates. Other indigenous species, very few of which can approach teak in the matter of expansion and contraction, have no long period between the date of felling and the time when they arrive at the railway workshops, and they must, therefore, be properly seasoned if satisfactory service is to be obtained from them. This is not so easy as it sounds, as the railways are very reluctant to carry large stocks of seasoned timber, nor have they the space in many instances to accommodate extensive stocks. In such cases, kiln-seasoning is the only remedy, but where space is available and a railway is willing to carry stocks for a few months, air-seasoning is often preferable, and, if properly done, can usually be completed in from 6 to 12 months.

Some of the timbers already used by the railways for carriage and wagon work are as follows:—

Tectona grandis ..	For all parts of carriages.
Shorea robusta ..	For wagon repairs and floor boards. (Not really suitable for this work as it is very prone to warping.)
Pterocarpus dalbergioides	For panelling, casing boards, etc.
Adina cordifolia ..	For seats and casing boards.
Cedrus deodara ..	For shutters, wagon boards, etc.
Dalbergia latifolia ..	For panelling and saloon furniture.
Dalbergia sissoo ..	For furniture and repairs, and for flooring, for which purpose it has proved very popular.
Acacia arabica ..	For bolster beams, pillars, framing, and floor boards.

For miscellaneous works:—

Xylia dolabriformis	..	For head-stocks, doors, and under-frames.
Terminalia tomentosa	..	For miscellaneous works and repairs.
Cedrela toona	..	For ceiling boards and luggage battens.
Lagerstroemia spp.	..	For wagon repairs.
Pentace burmanica	..	For wagon repairs.
Pinus longifolia	..	For roofing. *P. excelsa* would be better.
Pterocarpus marsupium	..	For brake vans.
Dipterocarpus spp.	..	Partition boards, etc.

Some of the timbers (other than teak) recommended for the various purposes of a railway workshop are the following. The list is not exhaustive and may very possibly be increased with experience:—

Pillars, rails, cross-bars.—*Pterocarpus dalbergioides, Pterocarpus macrocarpus, Pterocarpus marsupium. Albizzia lebbek, Lagerstroemia hypoleuca, Lagerstroemia flos-reginae, Dipterocarpus pilosus, Grewia tiliaefolia, Anogeissus acuminata,* and *Shorea assamica.*

Floor boards.—*Dipterocarpus tuberculatus, Dipterocarpus pilosus, Hopea odorata, Hopea parviflora,* and *Terminalia tomentosa.*

Roof and ceiling boards.—*Lagerstroemia hypoleuca, Terminalia procera, Phoebe hainesiana, Lagerstroemia lanceolata, Hopea odorata, Hopea parviflora, Gmelina arborea, Adina cordifolia, Calophyllum* species.

Partition boards.—*Lagerstroemia hypoleuca, Pinus excelsa, Pinus longifolia, Phoebe hainesiana, Cedrus deodara, Dipterocarpus tuberculatus, Hopea odorata, Hopea parviflora, Lagerstroemia flos-reginae, Terminalia tomentosa, Shorea assamica, Lagerstroemia lanceolata, Terminalia bialata,* and *Calophyllum* species.

Panelling and decorative work.—*Gmelina arborea, Adina cordifolia, Albizzia lebbek, Terminalia tomentosa, Pterocarpus dalbergioides* and *Pterocarpus macrocarpus, Dalbergia* species, *Terminalia bialata* (white chuglam), *Pentace burmanica,* and *Chukrasia tabularis.*

Doors and windows.—*Lagerstroemia hypoleuca, Acacia arabica, Gmelina arborea, Lagerstroemia flos-reginae, Pterocarpus dalbergioides, Dalbergia latifolia, Dalbergia sissoo,* and *Chukrasia tabularis.*

In conclusion, it should be remembered that railway carriage and wagon work is one of the largest uses to which timbers in India are put, and that although teak has been practically the only timber considered suitable for the purpose in the past, experience has shown that there are several other species which can be used as excellent substitutes for teak, provided they are made available in sufficient quantities and are properly seasoned before use. The introduction of metal

for railway carriage bodies is a proposition which must not be forgotten. As yet, its use has not proved altogether satisfactory, but with further improvements there is little doubt that it may be a serious factor affecting the utilization of wood for carriage and wagon work. Fibre boards are also coming into use in place of wood for panels and ceilings in railway carriage building.

Carts and carriages

The main parts of a cart or carriage are the framework, the axle, the wheels and the shafts or pole.

For the **framework,** a fairly *light* wood is preferable provided it is *reasonably strong* and *elastic.* If much strain or friction is likely, as in the case of country carts, a strong tough wood is essential. *Gmelina arborea, Dalbergia sissoo, Dipterocarpus* species, *Dysoxylum malabaricum, Eugenia jambolana, Lagerstroemia* species, *Shorea talura,* and *Terminalia bialata* are of the type of timber most suitable for the purpose. The first named is an excellent timber for light carts, while sissoo is one of the best woods on the market for the framework of carriages. *Shorea robusta* is often used, but it is really on the heavy side for this type of work. *Ougeinia dalbergioides* is another very popular bodywork wood.

For the **axles** of wheeled vehicles a *very tough hard* wood is essential. Such timbers as *Anogeissus latifolia, Acacia arabica, Heritiera minor, Xylia dolabriformis,* and *Pterocarpus macrocarpus* are among the best for the purpose, while *Shorea robusta* and *Dalbergia sissoo* are commonly used for axles in Northern India.

With regard to **wheels,** these are composed of 3 main parts, the nave or hub, the spokes, and the felloes.

For naves or **hubs,** a *very hard* and *tough* timber is desirable, as it will be subjected to great stresses, and it must be hard enough to prevent the spokes from working loose in the mortises in which they are inserted in the nave. Examples of typical nave or hub timbers are *Acacia arabica, Berrya ammonilla, Chloroxylon swietenia, Hardwickia binata, Hopea parviflora, Mesua ferrea, Pterocarpus macrocarpus, Shorea obtusa, Shorea robusta, Xylia dolabriformis,* and *Xylia xylocarpa.*

For **spokes,** timber should be preferably *straight-grained,* but must be *strong* and *tough.* It should also be *free from defects* and *not liable to warp or shrink,* the latter fault resulting in the spokes becoming loose in the mortises of the hub and felloes. The best woods for the purpose are *Dalbergia sissoo, Dalbergia latifolia, Pterocarpus macrocarpus,* and *Pterocarpus marsupium.* These timbers are the only four accepted by the Indian Gun Carriage Factory for the purpose, although they have slightly interlocked fibres, but other timbers such as *Acacia arabica, Anogeissus latifolia, Anogeissus acuminata, Heritiera minor,* and *Lagerstroemia flos-reginae,* being strong tough woods, are all of the type likely to make good spokes. *Vitex leucoxylon* is popular for this purpose in Madras.

For **felloes**, *durability* is desirable in addition to *strength, hardness, and elasticity*, as the circumference of a wheel is subjected to alternate wetting and drying. especially in rainy weather and when the vehicle is driven through water. To make a really strong wheel, curved timber is the best, but in any case the grain of the wood should follow the line of the circumference of the wheel as nearly as possible, and felloes with the grain running across their length should be avoided.

For the **rims** of light wheels, steam-bent wood is sometimes used, but steam-bending in India is not a common practice. All the timbers mentioned as suitable for spokes are suitable also for felloes, while *Ougeinia dalbergioides*, *Acacia catechu*, and *Albizzia* species are also commonly used. In some parts of India, more especially in Madras, Bengal, Bombay, and Burma, solid wheels are made of one piece of wood, or of 3 pieces held together by an iron tyre. The woods most commonly employed for this purpose are teak, *Acacia arabica*, *Hopea odorata*, *Mangifera indica*, *Shorea robusta*, *Terminalia tomentosa*, *Vitex leucoxylon*, and *Xylia dolabriformis*.

For **shafts and poles**, a *straight-grained, strong, tough, and elastic* wood is essential. Sal (*Shorea robusta*) is at present the standard wood used by the Government Gun Carriage Factory at Jubbulpore, but it is considered to be rather heavy for the purpose. Such timbers as *Grewia tiliaefolia*, *Anogeissus acuminata*, *Anogeissus latifolia*, *Homalium tomentosum*, *Shorea talura*, and *Pterocarpus dalbergioides* are of the type likely to be most suitable. Bamboos are very commonly used for buggy shafts, being light and strong, and split wood is also popular for shafts for the lighter types of carriages. *Pterospermum suberifolium* is used for this purpose in South India.

Motor-car bodies

Wood is used to quite a considerable extent for bodywork, hood frames, and wheel spokes in motor-car construction. The best woods for motor-car bodies are those already mentioned in connexion with the bodywork of carriages, the chief requirements being *strength, resistance to fungus attack*, and *freedom from 'movement' combined with lightness*. The timber must also be sufficiently *hard* to withstand friction and wear and tear in bolt holes and mortise joints, and must be a wood which will take a high finish of paint or polish, except in the case of woods required for those parts with a rough finish such as floor boards and seat parts. *Gmelina arborea*, *Artocarpus hirsuta*, and *Calophyllum* species are all good woods for the purpose, although the first named is a little weak for those parts where much strength is required. *Dipterocarpus turbinatus*, *Terminalia bialata*, *Dysoxylum glandulosum*, and *Terminalia manii* were given extensive trials in England in 1924 and were reported on as extremely satisfactory. *Lagerstroemia lanceolata* is used extensively in Madras for motor bodies.

For **hood frames**, a fairly *strong elastic* and *tough* wood is desirable, and as such members are usually used bent, the wood should be one which is not liable to snap. *Dalbergia sissoo*, *Terminalia bialata*, *Morus* spp. and *Gmelina arborea* are all good woods for the purpose.

For motor-car **wheel spokes**, ash is usually used, but *Dalbergia sissoo* makes an excellent substitute. Metal is, however, gradually replacing wood for motor-car wheel work, and the demand for wood for this purpose is decreasing.

Aeroplane members

The specification of timber for aircraft use is very severe, and the number of species accepted is very small. For main members, imported Sitka spruce (*Picea sitchensis*) is practically the only species used at present in India. Spruce (*Picea morinda*) and fir (*Abies pindrow*) would, however, be accepted if they could be obtained in the sizes and up to the specifications required by the Royal Air Force. The extraction of these two species, in the long lengths required and free from knots, is however a problem which has not yet been solved. It must be remembered that aeroplanes are usually constructed of different materials, of which wood is the only one that is used in its natural state, and it is obvious that such woods as are used must be of the very best, not only in quality of texture but also in formation and growth. If the wood fails, it is like the fracture of a link in a chain, and the whole structure fails. Straight-grained clean wood is essential for aircraft work.

For certain parts of aeroplanes English ash (*Fraxinus excelsa*) and American rock elm (*Ulmus racemosa*) are used, but white chuglam (*Terminalia bialata*) from the Andaman Islands has been approved as a substitute for these two woods. For other parts, American black walnut (*Juglans nigra*) is the standard, but Andaman padauk (*Pterocarpus dalbergioides*) and Indian rosewood (*Dalbergia latifolia*) are accepted as substitutes.

For **propeller work**, several Indian woods have been tested and proved good. Amongst these are *Albizzia odoratissima*, *Pterocarpus dalbergioides*, and *Pterocarpus macrocarpus*.

For **tail skids**, American ash or hickory used to be the standard timbers, but *Anogeissus acuminata*, *Terminalia tomentosa*, and *Grewia tiliaefolia* have all proved good substitutes. In addition to the use of wood in solid form, it may also be noted that plywood is used extensively for fuselage covering and other parts of aeroplane construction, and being light and strong is eminently suitable for the purpose. Laminboard is also increasing in use for aircraft work.

Finally, it must not be forgotten that aeroplanes are being constructed very largely of metal nowadays, and although the demand for wood will continue for certain parts, the use of wood in aircraft construction is not so great as it was.

Tool Handles

Carpentry tool handles

A considerable amount of wood is used up annually in making handles for chisels, saws, gimlets, screwdrivers and such-like tools, and for the blocks of planes and similar utensils of a carpenter's craft.

The handles of most imported tools are made of box (*Buxus sempervirens*), beech (*Fagus sylvatica*), birch (*Betula* species), and ash (*Fraxinus excelsior*), but in India, except for a limited supply of box, these timbers are not available, and carpenters have to make use of such local woods as are most suitable for their purpose.

The chief qualities required for such tool handles are *closeness of grain, toughness, hardness,* and *non-liability to split.* The wood must be one which will work up to a smooth finish, so as to preclude the possibility of any roughness on the wood surface making a sore on the hand. In addition, it must be hard enough and tough enough to stand blows from a hammer or mallet and must not splinter under such blows.

Such woods as *Pterocarpus macrocarpus, Mesua ferrea, Parrotia jacquemontiana, Olea ferruginea, Acacia arabica, Anogeissus latifolia, Dalbergia latifolia, Dalbergia sissoo,* and *Xylia dolabriformis* are excellent for the purpose; and *Cassia fistula, Mesua ferrea, Murraya exotica, Ougeinia dalbergioides, Schleichera trijuga,* and *Tamarindus indica* are all commonly used in the localities where they occur.

Axe, pick, and hammer handles

The quantity of wood used annually in India for axe, pick, and hammer handles is very large.

A recent census of the hammer and tool handles used by the railways in India showed that 14 railways used nearly 500,000 handles per annum, and that the majority of this number were of imported wood.

If the handles used by the Army, Public Works Departments, coal mines, and other public and private concerns are added to this total, there is little doubt that the annual consumption in India exceeds 1,000,000 handles. Tool handles are therefore a big market in this country, and as most of the handles used are imported from Europe and America, there is a good opening for indigenous timbers. The woods of which imported handles are made are ash (*Fraxinus* species) and hickory (*Hicoria* species). Both these woods are strong, tough and elastic and are capable of withstanding the continuous shocks resulting from the use of the tools. They are also both straight-fibred woods which split with a long fracture. In India, there are some excellent substitutes for ash and hickory for tool handle work. *Parrotia jacquemontiana, Sageraea elliptica,*

and *Olea ferruginea* have proved so far to be the best, but their use is very limited owing to the poor supplies available. Other good tool handle woods are *Grewia tiliaefolia*, *Anogeissus latifolia*, and *Anogeissus acuminata*. These timbers compare very favourably with ash, and in some strength tests approach the unique qualities of hickory. *Anogeissus pendula* is another outstandingly strong wood.

Many other species are used for the purpose throughout India; some being good and others definitely unsuitable. Amongst the best are *Acacia arabica*, *Cynometra polyandra*, *Dalbergia* species, *Diospyros* species, *Mallotus philippinensis*, *Mesua ferrea*, *Ougeinia dalbergioides*, *Quercus dilatata*, *Quercus incana*, *Schleichera trijuga*, and *Terminalia tomentosa*, and there are undoubtedly many others which are as good, but which have not yet been scientifically tested for the purpose.

In conclusion, it must not be forgotten that the male bamboo (*Dendrocalamus strictus*) is largely used in many parts of India for axe handles, the eye of many Indian axes being round. It makes a good tough handle, but it has the disadvantage of being suitable only for round eyes, and the nodes are a drawback on handles of large tools when the hand is allowed to slip up and down the handle while the tool is in use.

Boxes, Crates, and Packing-cases

In India, the manufacture of packing-cases is not an intensive industry, except in connexion with certain commodities such as tea, coffee, opium, tobacco, and kerosene oil.

On the other hand, the amount of wood used for packing-cases in this country is very large, but instead of being a specialized industry as in America, the making of boxes and crates in India is usually done as and when required to suit the needs of the moment.

Local and imported woods are used for the purpose, but a large number of packing-cases, crates, and boxes are made from the wood of used imported cases. India imports large quantities of machinery and stores from Europe and America, and as such articles are invariably packed in wooden cases a good supply of suitable timber is usually available for breaking up and re-making into fresh cases. The timber of which these imported boxes is made is usually 'deal'.

'Deal' is a comprehensive term and includes the woods of several conifers. The most common deal is the red or yellow deal, the wood of the Scotch pine (*Pinus sylvestris*), and when talking of deal in general terms, the reference is usually to the timber of this species. Another common deal is known as white deal, a name which generally refers to the wood of the common spruce (*Picea excelsa*), but the term 'deal' is nowadays so loosely applied that it may be said to include any timber of the soft coniferous variety. It would, therefore, be

quite correct to refer to the timber of most of the Indian conifers, and especially *Abies pindrow*, *Picea morinda*, and *Pinus excelsa*, as deal woods.

Returning to the subject of packing-cases, the important thing to remember is that the majority of packing-cases and crates made in India are made of deal wood imported from abroad, and so long as a good supply of cheap imports is available the practice will continue. There still remains, however, a demand for indigenous woods for the same purpose, and it is these timbers which will now be considered.

In the first place, it must not be thought that any wood is suitable for making into packing-cases. The requisite qualities for such work are *lightness*, *ease of working*, and *non-liability to split* when nails are driven into the wood. *Freedom from shrinking and warping* are also important, and the wood must *not contain any colouring matter or have an odour* which will injure the contents of the box. This last point applies more particularly to boxes for foodstuffs such as butter and fruit. Finally, woods for packing-cases must be *easily available and cheap*. Such woods are to be found in most parts of India, but the cost factor is one which often mitigates against the more extensive use of Indian woods for this purpose, and instances are not lacking where firms find it cheaper to import box woods in the form of shooks cut to required sizes, rather than use a supply of local or indigenous timber. White woods are preferred to coloured woods.

The best box and crate woods in India are such woods as *Duabanga sonneratioides*, *Dysoxylum malabaricum*, *Mangifera indica*, *Bombax malabaricum*, *Bombax insigne*, *Holoptelea integrifolia*, *Terminalia bialata*, *Canarium* species, and the conifers *Pinus longifolia*, *Picea morinda*, *Abies pindrow*, and *Pinus excelsa*. The Andamans are especially rich in good box woods, dhup (*Canarium euphyllum*), lambapatti (*Sideroxylon longepetiolatum*), semul (*Bombax insigne*), papita (*Sterculia campanulata*), bakota (*Endospermum malaccense*), and red dhup (*Parishia insignis*) being good examples. *Tetrameles nudiflora* is also used extensively.

Duabanga sonneratioides is one of the best box woods in Bengal and Assam, while *Holoptelea integrifolia* has proved to be an excellent packing-case wood in the United Provinces. It is now used by the Ordnance and Army Departments in place of teak for packing-cases and army boxes.

In Madras, *Alstonia scholaris*, *Antiaris toxicaria*, and *Vateria indica* are largely used for box and crate making in the western districts, while semul (*Bombax malabaricum*) is used in large quantities in Calcutta, one firm consuming 300 tons of semul every month for the manufacture of box shooks.

Swintonia floribunda is accepted by the Burma Oil Company for their kerosene oil packing-cases, and *Anacardium occidentale* is used for indigo boxes in Madras. *Boswellia serrata* is another common box wood, both in Bengal for mica boxes,

and on the Bombay side for general packing-case work. *Cedrus deodara* is a good wood for high class boxes where its odour is not objectionable, and the Ordnance Department use it for army stores, but its price usually precludes it for cheap work.

Terminalia belerica is a popular wood in Madras for coffee boxes, while the fruit crates and grape boxes from North India are usually made of *Populus* species. Cigar boxes in Madras are a special line in themselves, and a timber of the 'cedarwood' variety is demanded. The timbers most commonly used for this purpose are *Cedrela toona*, *Melia azadirachta*, and *Melia composita*, while *Homalium zeylanicum* was selected as a very suitable wood for tobacco casks.

Tea boxes

The manufacture of tea boxes is a specialized industry, and one which concerns India in no small degree. Until comparatively recently, tea in India was packed and exported in chests made of solid wood shooks. Originally these shooks were hand-sawn, but later sawmills were established and a flourishing industry grew up. Up to 1912, 73 per cent of the requirements of the Assam tea industry were supplied by locally made shook chests. Of late years, however, 3-plywood boxes have supplanted the solid shook chests. This was inevitable, as the 3-ply chest has many advantages over the solid shook box. In the first place, a plywood tea chest weighs between 16 lb. and 18 lb. as against 28 lb. for the solid chest, and as regards strength, plywood is in general terms about three times as strong in tensile strength as a solid plank of the same timber. As a result, it has been found possible to use a 2 oz. lead lining in plywood tea boxes whereas a 4 oz. lining is necessary in the solid shook box to withstand the strain.

The 3-ply tea chest has, therefore, practically ousted the solid shook chest in India, and the number of plywood chests now used in this country is in the neighbourhood of 5,000,000 per annum. The most common size of tea chest is $19'' \times 19'' \times 24''$, and over 50 per cent of the chests now used in this country are of this size. Four other sizes are made use of, but the $19'' \times 19'' \times 24''$ chest containing 120 lb. of tea is by far the most important. At present only about 400,000 boxes out of the 5,000,000 tea boxes used annually in this country are made in India, the remainder being imported plywood boxes of such well-known brands as 'Venesta', 'Hercules', 'Luralda', and about 150,000 of country-made solid shook boxes.

The timbers used in the manufacture of the imported boxes are usually birch (*Betula alba*) and alder (*Alnus glutinosa*). The requisite qualities of woods for commercial plywood tea boxes are *availability and cheapness, freedom from heart and star shakes, freedom from interlocked fibres, lightness combined with reasonable strength, and non-liability to taint the tea or corrode the lead and aluminium linings of the boxes.*

The timbers now being used in India are hollong (*Dipterocarpus macrocarpus*) and hollock (*Terminalia myriocarpa*), the two most common and most suitable woods occurring in the neighbourhood of the two existing teabox mills in India, both of which are situated in Assam. *Chukrasia tabularis*, *Cedrela toona*, *Shorea assamica*, and *Michelia oblonga* have also been used to a lesser degree, but supplies are limited.

For solid shook boxes, *Bombax malabaricum*, *Cedrela toona*, *Mangifera indica*, *Duabanga sonneratioides*, *Sterculia villosa*, and *Tetrameles nudiflora* are the most used woods but, as mentioned above, the demand for solid shooks for tea chests is on the decline.

From the above few remarks on the tea chest industry, it will be seen that there is a big opening for the utilization of indigenous woods in this direction. Only one-tenth of the tea boxes used in India are made in the country, and provided good quality plywood chests can be manufactured at prices which compare favourably with the imported article, there should be no limit to the expansion of plywood manufacture in India and the consequent consumption of large quantities of indigenous woods. The chief difficulty in the way of the expansion of the industry in India is the lack of sufficient timber of suitable species in or near one locality. A plywood factory, in order to be a paying proposition, requires at least 4,000 tons of timber per annum, preferably of one species.

Opium chests

The number of opium chests used in India is small compared to tea chests. Actually, only about 20,000 are used annually. Of these, about half are of imported plywood and the other half of solid country-made shooks. The inside dimensions of an opium chest are $34\frac{3}{8}'' \times 26\frac{1}{8}'' \times 14\frac{1}{4}''$, and the inside of the chest is divided into partitions for holding the cakes of opium. Mango (*Mangifera indica*) is used for the solid shook boxes, and semul (*Bombax malabaricum* and *B. insigne*) are used for the inside partitions. *Abies pindrow* and *Sonneratia apetala* are also reported to have been tested and pronounced suitable for opium chests. Many other woods would be quite suitable for the purpose, and the list given for tea boxes applies equally well in this case.

Rubber chests

The average export of rubber from India is in the neighbourhood of 26,000,000 lb. per annum. The average weight of rubber in each chest is about 220 lb., so roughly over 100,000 boxes are required annually for this trade. The size of the boxes varies considerably, and boxes containing from 20 lb. to 400 lb. of rubber are actually in use. In former years, solid boxes only were used, but plywood chests are now ousting the old-fashioned shook box, and tea chests

are not infrequently used for the purpose. Bulk for bulk, rubber is a good deal heavier than tea, and strong boxes are, therefore, very necessary for the former, but except for this point, the remarks made concerning timbers for tea boxes apply equally well to boxes for rubber.

Candle boxes

The only other industry which deserves special mention in connexion with box manufacture is that of candle boxes for the Indian oil companies.

Candles are sent out in boxes approximately $27'' \times 19'' \times 10''$. These boxes are made from shooks cut to the required sizes, and up to the present time the supplies have all been of imported deal wood. The essential features of the timber used for such boxes are that it shall be *light in colour, reasonably strong*, and above all *plentiful and cheap*. The reason for the light colour is that stencil markings may be clearly seen and that the box may appear newly made. This last point is considered important by the oil companies. In addition, great stress is laid on the necessity for the wood to be seasoned, as a damp wood is said to have a very deleterious effect on the contents of the box. There are undoubtedly timbers in India which would be very suitable for this market, but unfortunately there are no large box factories in India which can deal with big orders of this kind, and the seasoning difficulty is ever present. An effort was made some years ago to induce one of the largest oil companies in the country to use lambapatti (*Sideroxylon longepetiolatum*) from the Andamans for candle boxes. The wood of this species, known in some markets as ivory white wood, would have been ideal for the purpose, but so far business has not resulted, owing to the lack of a large box-making firm in India which could produce box shooks at prices comparing favourably with those of imported deal shooks. This incident illustrates very clearly the necessity of box timbers being cheap. In fact, box manufacture may be considered the last resort of timber utilization, and only those common and plentiful woods for which a good price cannot be obtained for other purposes stand any chance in the competition with imported deals. Such timbers as *Boswellia serrata, Mangifera indica, Bombax malabaricum, Tetrameles nudiflora*, and *Sterculia* species are examples of such woods. *Anthocephalus cadamba* is used in Burma for box work and has been found suitable for the purpose and enjoys a local demand. *Swintonia floribunda* is another wood which should be suitable for this type of work.

Matchboxes and Splints

The match industry is one of the most important timber-using industries of the world. It has been estimated that the yearly world consumption of matches is 3,228,425,000,000, requiring over 100,000,000 cubic feet of wood.

In India, the annual consumption of matches is in the neighbourhood of 15 to 18 million gross. Up to 1921, all the matches used in India were imported, and it was not till 1922 that the growth of the match industry in India really started, as the result of a duty imposed on imported matches. Prior to this, small factories had been established from time to time, but in almost every case they were soon closed down, either because they were situated in unsuitable localities or on account of insufficient capital or faulty management.

With the imposition of an import duty, however, the position changed rapidly, and imports dropped from 14 million gross in 1921-2 to about 4 million gross in 1927-8. At first, raw (undipped) splints and veneers were imported from Japan and Sweden, and made into finished matches and boxes in India, as no duty was levied on undipped splints and raw veneers, but when in 1924 Government imposed a duty on these materials, India woke up to the fact that match splints and boxes could be made profitably in this country, and the indigenous industry had an instant revival. Match factories began to spring up throughout the country, and there are now some 30 or more factories manufacturing splints and matchboxes in India. For the first few years after the revival in 1921, aspen (*Populus tremula*) was still the most used wood for splints and boxes, but indigenous timbers gradually began to take its place as they became known. All Swedish matches are made of aspen, while Japanese matches are made of timbers known as *shina-no-ki* (*Tilia japonica*) and *hakuyo* (*Populus tremula*), and the well-known English 'Swan Vestas' are made from grooved sugar pine (*Pinus lambertiana*).

The process of making matches and boxes is made simple by the introduction of extremely efficient machinery, and in up-to-date factories the efficiency and almost human attainments of the machines must be seen to be believed.

The actual process of manufacture is briefly as follows. The logs are first sawn into short lengths and placed on a rotary lathe. Each lathe is adjusted according to the thickness of veneer required, which may be for boxes or splints. The logs are then rotated against a fixed knife blade and the veneer is peeled off in a continuous sheet. Veneers required for boxes are scored by means of super knives attached to the lathe, so that the required size and shape are easily obtainable afterwards by merely bending the veneer. Separate machines are then brought into action for making the outer and inner boxes. These machines are automatic and only require to be fed with veneers, paper and glue, to turn out boxes in a finished condition.

The splints are made by chopping the veneer into the required sizes by means of a guillotine chopper. They are then immersed in a special solution to prevent glowing after the flame is extinguished, and are afterwards dried and polished in a cylindrical revolving drying machine. They are then ready for paraffining

and dipping in the lighting composition, which is done by placing the splints in a frame covered with slits into which the splints are shaken, so that they stand in an upright position in which they are held tight. The frames are then immersed to the required depth in the paraffin and lighting composition and dried. The matches are then removed from the frames and are ready for filling into the boxes.

In the most up-to-date machines the two processes of paraffining and dipping are done on one continuous machine, which automatically loads itself with splints, dips the splints in paraffin and the lighting composition, dries them, and finally ejects them for filling into boxes.

A 'full size' matchbox is $2\frac{21}{24}'' \times 1\frac{15}{32}'' \times \frac{23}{32}''$, and two other sizes are commonly manufactured, namely the 'three-quarter' size and 'half' size. Two kinds of matches are made, viz. safety matches which ignite by friction on a specially prepared surface on the side of the box, and sulphur matches which ignite on any rough surface, due to the phosphorus contained in the head.

The timber from which matches and boxes are made is naturally an important item in the manufacture, and strange though it may seem there are very few woods in India which are really good for the purpose. The essential factors in the selection of match woods are *straightness of grain, good fissility, strength and toughness combined with lightness, good white colour, freedom from knots*, and above all the wood must be *easily available and cheap*, and the logs must be round. This is a severe list, but a quick survey of each factor will show how necessary each item is in the production of good quality matches.

In the first place, if a wood is not straight-grained, it will not peel well, and the resultant splints will not have the wood fibres running along their length to give them strength. If the fibres run across the splints, the match will break on striking. Fissility is necessary for the same reason, and a wood which will not easily split on the guillotine chopping machine is useless. For this reason woods with twisted or 'interlocked' fibres are no good.

As regards strength, a very strong hard heavy wood is unsuitable. Such woods are not easily impregnated, and the ideal is a combination of strength with lightness. The ideal wood should also be pliable or tough. Brittle woods cannot be peeled, and they break off in short lengths. In addition they do not fold well when being bent up into box form. They also make weak splints which break on striking.

As regards colour, this is an important factor from the manufacturer's point of view, as the public demand a white match. Actually, there is no difference between the suitability of a coloured wood and of a white wood, but popular prejudice demands the latter, and there is no sale for matches made from coloured

woods in India, though matches dyed pink or yellow command a big sale in some countries.

Freedom from knots is desirable on account of the wastage in having to discard knotty timber which is unsuitable for peeling on the lathe, or which, though suitable for peeling, is useless for boxes or splints. In the same way, all logs for veneer peeling should be as nearly cylindrical as possible. Fluted or eccentric logs are very wasteful in peeling, as a large proportion of the wood is lost before a continuous veneer starts to come off the machine.

Finally there is the question of availability and cheapness. Such timbers as *Betula utilis*, and *Alnus nitida*, if they could be obtained green in suitable sizes on the plains of India, would probably make good matches, but their inaccessibility and consequent high price delivered at match factories rules them out.

India is therefore compelled to turn to such plains' timbers as are available in good quantities at cheap rates, but when the other necessary factors are taken into account, the number of timbers so far found to be suitable for match manufacture is very limited.

Aspen (*Populus tremula*), the best known wood for match work, does not grow in India, nor has it been possible, so far, to find an Indian wood which is just as good. Many timbers have been tried, and some have been found fairly suitable for match-making, but no wood yet tried has come up to the standard of aspen. The above remarks refer more specifically to splint manufacture, for which purpose it is more difficult to find a suitable wood than for box-making. There are several woods in India which have been reported upon by factories as definitely suitable for boxes, and it is not uncommon to find boxes made from Indian woods filled with aspen splints. The following woods are those which are now being used in India for box and splint manufacture:—

Bombax malabaricum (semul)	Very good for boxes. Does not make very good splints, but is being largely used for the purpose.
Albizzia stipulata ..	Sapwood good for splints and boxes but heartwood wrong colour.
Sterculia campanulata (papita)	Makes good boxes and fair splints. Used on a large scale in Calcutta and Burma.
Excaecaria agallocha (geon)	Good for splints. Used in Calcutta factories.
Endospermum malaccense (bakota)	Largely used in Calcutta for splints and boxes.
Evodia roxburghiana	Very good. In great demand on the west coast for matches.
Populus nigra ..	Largely used by Punjab match factory.

Canarium species (dhup)	Used in the Andamans for boxes and splints.
Sarcocephalus cordatus (*ma-u-lettan*)	Used in Burma match factories for boxes and splints.

The following species have also been tried and found suitable for match work, but are not used on such a large scale as the timbers mentioned above:—

Sideroxylon longepetiolatum (lambapatti)	Very good. Possibly the best wood yet tried for the purpose, but supplies are limited.
Trewia nudiflora ..	Fair for splints and good for boxes.
Mangifera indica ..	Suitable for second-quality splints if colour is suitable.
Holigarna arnottiana ..	Good for splints and boxes.
Hymenodictyon excelsum	Can be used for splints and boxes.
Lophopetalum wightianum	Reported to be very good for splints and boxes.
Bombax insigne ..	Suitable for boxes.
Vateria indica ..	Reported on as good for splints and boxes.
Symplocos beddomei ..	Reported on as very good for splints and boxes.
Stereospermum chelonoides	Reported on as good for splints and boxes.
Holoptelea integrifolia ..	Reported on as good for splints.
Broussonetia papyrifera ..	Would be suitable for boxes if straight-grained wood is obtained.
Cinnamomum zeylanicum	Good for boxes.
Eugenia caryophyllaea ..	Suitable for boxes.
Alstonia scholaris ..	Has been used for splints and boxes.
Anthocephalus cadamba ..	Suitable for splints and boxes, but wood is apt to discolour.
Ailanthus species ..	Suitable for boxes. Used in South India for splints.
Spondias mangifera ..	Reported on as good for splints.

From the above lists it will be seen that there are several woods in India which can be used for match manufacture. Opinions may vary as to the exact degree of suitability of different species, but all are agreed that none of the timbers above mentioned can compare with aspen.

The most-used species at present are semul, dhup, papita, and bakota, the last three being Andaman woods which are dispatched into India either in the form of small logs, or in the form of veneers and splints which are made up into boxes and matches in India. Aspen still holds its own for the higher class

matches, but every year sees improvements in the quality of Indian matches, and it does not seem improbable that the aspen match will, before long, disappear from the Indian market. Efforts have been made from time to time to manufacture match splints and boxes from bamboos, reeds, and grasses, but the results have seldom been satisfactory. At one time, the *eta* reed (*Ochlandra travancorica*) looked like fulfilling the hopes held out in this direction, and matches and boxes of this reed were actually made on a large scale in Cochin State, but the enterprise failed for various reasons, the chief of which was the impossibility of obtaining reeds of uniform size, or of devising machinery to deal with reeds of varying diameters. Theoretically, bamboos and reeds should make excellent matches as they have all the necessary qualities, but in practice they are ruled out as no machinery has yet been invented to convert them into splints and box veneers.

Before passing from the subject of matches, the fact that many match woods in India are very liable to blue stain and fungus attack should be recorded. This trouble can, however, be overcome by soaking the splints in a 4 per cent solution of zinc sulphate or a 0·2 per cent solution of mercuric chloride.

Splitwood

Cooperage

Cooperage comprises the manufacture of all kinds of barrels, casks, tubs, drums and similar vessels for holding liquids or dry goods. There are two distinct types of cooper's work, namely tight cooperage and loose or slack cooperage, the former referring to vessels for liquids such as oils, beer, and wines, and the latter to containers for dry goods such as cement, flour, salt, lime, and solid chemicals such as rosin.

For **tight cooperage,** it is essential to have a *strong* and *durable* wood, which will remain watertight. *The shrinkage value and impermeability of the wood are, therefore, of importance,* and in addition, *straightness of grain and good fissility* are necessary, while the wood must not contain any substance which will contaminate the contents of the barrel, by giving it an undesirable taste, odour or colour.

For **loose cooperage,** much *the same requirements* are necessary, except that impermeability of the wood is not so important. What is important is that the wood should be *cheap* and *easily available,* since loose barrels have to compete with many other forms of cheap containers such as sacks, paper and cloth bags, wooden boxes, and cartons. In addition, *weight is of importance,* and provided the wood is strong enough to support the contents, the lighter it is the better, so that freight charges are kept at a minimum.

Finally, *a light coloured wood is preferable to a dark wood*, as trade marks and shipping instructions have to be stencilled on practically all types of containers and the trade will not accept a dirty-coloured or very dark wood.

The cooper's craft is a very ancient art, and historical records show that various forms of cooperage were in common use among the Romans, and even in early Biblical times. In most of the common forms of cask or barrel, the construction consists of pieces of wood bound together by hoops. The three components necessary for this form of construction are side staves, head pieces, and hoops. The staves are usually made by splitting wood when newly felled, by means of a cleaving tool, but in large modern factories machine sawing and riving is more often resorted to. The splitting is done in a radial direction, since shrinkage, and consequently leakage, is less with wood split in this way than in wood split tangentially. After splitting, the staves are shaped and bent to the required curve, the finished stave being thinner and narrower at the ends, with a broader and thicker centre to allow for the bulging round the middle of the cask.

The head pieces are usually flat, but in large casks sometimes curve inwards to withstand the pressure of the contents. The hoops are made of iron, except in the case of light temporary containers which are sometimes bound with split strips of pliable wood of such timbers as elm, ash and birch, or young coppice shoots of willow and hazel. In the highest grades of tight barrels the head pieces are dowelled to ensure a tight joint, but in loose cooperage the boards of the head pieces are more often than not joined with a plain butt joint, similar to the joints of the side staves.

Side staves may vary considerably in length according to the use to which they are to be put. Hogshead staves are over 4 ft. in length, while the ordinary wine barrel stave is about 3′ 2″ to 3′ 4″ in length. The breadth and thickness of staves also varies considerably according to the size of container, but even in the same barrel, staves of widths varying from 2″ to 4″ may be found.

In Europe and America, the chief wood used for tight barrels is oak (*Quercus* species), and for wine casks no other wood is accepted by the trade, except chestnut in the case of inferior barrels for very cheap wines. In India, several woods have been tried by the breweries, the most successful being *Grewia tiliaefolia*, *Grewia vestita*, and *Ougeinia dalbergioides*. *Quercus dilatata*, the *moru* oak, has also been found good and has been used on a large scale by breweries in North India, while *Quercus semiserrata*, the Burmese oak, and *Picea morinda* (spruce) have also been accepted for brewery work and reported on favourably. *Quercus incana*, the *ban* oak, on the other hand, is useless owing to its liability to split and warp.

Other woods tried for tight cooperage and well reported on are *Albizzia procera*, *Dalbergia sissoo*, and *Lagerstroemia hypoleuca*, while *Dysoxylum malabari-*

cum has been found useful in South India for coconut-oil casks. Teak is also a good barrel wood where its odour is not objectionable. For slack cooperage in the form of cement casks, rosin barrels, etc., there are several Indian woods which have been proved suitable. Amongst the best are *Odina wodier*, *Boswellia serrata*, *Saccopetalum tomentosum*, *Bombax malabaricum*, and *Tetrameles nudiflora*. *Pinus excelsa*, *Abies pindrow*, and *Picea morinda* are also used in the Punjab for rosin casks. *Bombax malabaricum* and *Tetrameles nudiflora* have also been tried for oil casks and found excellent for the purpose.

In the case of some dry goods such as sugar and salt, barrels are often made of one sheet of wood peeled from a log on a rotary peeling machine. Such forms of drums are cheap to make and very light. They are, however, only used in small sizes and are not very strong.

Tent pegs, trenails, railway keys, etc.

Trenails are large wooden pegs of different sizes up to 28 inches long and 3 inches thick. The larger sizes are used in ship-building and are usually made of teak, while the smaller sizes, often called dowel pins, are used in joining and cabinet-making in place of nails. Tent pegs may vary in size from the small 6″ pegs used with very light tents, up to the large heavy pegs 3′ long and 4″ thick used with big marquees.

India being a country where a lot of camping is done, especially where the Army is concerned, there is a big demand for suitable woods for tent pegs of all descriptions.

Such woods must be *hard, durable,* and *tough enough to resist hammering*. Many Indian woods are admirably suited for the purpose. Among the best of these are *Acacia arabica*, *Heritiera minor*, *Ougeinia dalbergioides*, *Tamarindus indica*, and *Zizyphus jujuba*.

Other good tent peg woods are *Dalbergia sissoo*, *Pterocarpus macrocarpus*, *Shorea robusta*, *Grewia* species, *Anogeissus* species, and *Xylia* species.

The most common type of peg seen in India is a round peg cut from a small branch or sapling. This type of peg is easily prepared but is very liable to crack, the wood being more often than not quite green. A more satisfactory peg can be sawn from a plank of seasoned wood to the size and shape required. Pegs of this latter type are now used in large quantities by the Ordnance Department. They are usually flat-sided and about three-quarters of an inch or one inch thick, pointed at the lower end and shaped with a notch at the top end to hold the rope.

Other uses

Shoulder poles.—These are usually made from splitwood, though bamboos are also largely used. The timber employed for such a purpose must be *very*

strong, tough, and elastic, and must be free from all weakening defects such as knots and insect holes. Suitable woods for this use are *Anogeissus acuminata, Anogeissus latifolia, Capparis aphylla, Cotoneaster bacillaris, Grewia* species, *Mesua ferrea*, and *Sageraea elliptica*.

Plaited wooden baskets.—These are not seen in such quantities in India as they are in Europe and America, where they are used for the carriage and marketing of fruit and vegetables. With the increase in the sale of fruit in India now visible, it is possible that the demand in this country may increase. Straight-grained spruce wood is used for the purpose in Europe, and there is no reason why Himalayan spruce and silver fir should not do equally well. The wood used for this purpose has to be thoroughly soaked in water and cut into bars, which in turn are split into thin pieces down the annual rings. The strips so produced are extremely flexible, and can be plaited with ease into any shape or size of basket required.

Sporting Requisites

Billiard cues

The shafts of billiard cues are usually made of European ash (*Fraxinus* species) or maple (*Acer* species), but there are several Indian woods which are quite suitable for the work.

The important points to remember about a billiard cue wood are that it must be of the *right weight*, and must have a *long-fibred straight grain*. The wood must be *white* or nearly so, and must be *free from defects* such as small knots or flecks. The weight required is about 42 lb. per cu. ft. (ash is 40–45 lb. and maple about 38 lb. per cu. ft.). Strength is not very important but *freedom from warping* is essential.

The three timbers which have been tried and found most suitable in India are *Diospyros melanoxylon, Grewia tiliaefolia*, and *Polyalthia fragrans*.

Bows and arrows

The wood found most suitable for bows in Western countries is yew (*Taxus baccata*), and yew wood has been used for centuries for this purpose. It is a very strong, tough, and elastic wood and has never been superseded by any other species for bow-making. In India, yew is found only in the Himalayas at 5,000 ft. elevations and over, but where it grows it is well known to local villagers as an excellent bow-wood. Other good woods used for this purpose are *Acacia catechu* (Burma), *Parrotia jacquemontiana* (Punjab), *Sageraea elliptica* (Andamans), *Berrya ammonilla* (Burma), and *Grewia* species (U.P.). *Sageraea listeri*, known as Andaman bow-wood, is an excellent wood for the purpose. Many other woods are employed for bow-making by local *shikaris*, and in a great many districts

bamboos are popular for this purpose. The latter make good strong bows but are wanting in elasticity.

Arrows may be made of any good strong wood which will remain straight and not warp. If an arrow has warped it is impossible to shoot straight with it. Conifers are sometimes used but are really too light for the purpose, and slightly heavier woods such as *Dalbergia sissoo, Gmelina arborea, Calophyllum* spp., *Pentace burmanica,* and *Pterocarpus marsupium* would be more suitable. Reeds and bamboos are also commonly used for arrows and are very suitable for the purpose.

Cricket bats

The best and only cricket bat wood used is willow (*Salix* spp.) and no other species has yet been found suitable for this purpose. The Kashmir willow from which cricket bats are made in India is a hybrid species, *Salix alba* x *fragilis.* Attempts have been made to find substitute woods in India, but without success, and attention has now been turned to planting suitable willow species in hill districts.

Croquet balls and mallets

For croquet balls and mallets the only wood found suitable is *Buxus sempervirens* (box). The two essentials are weight and closeness of texture, and *Olea ferruginea* might, therefore, make a good substitute for box for this purpose, as it is one of the heaviest Indian woods and has, in addition, an extremely close texture.

Fishing rods

The wood most commonly used for high class solid fishing rods is greenheart (*Nectandra* species), but this wood does not grow in India. It is indigenous in British Guiana (South America). Several substitutes have been tried in this country, and black chuglam (*Terminalia manii*) and chooi (*Sageraea elliptica*) proved good, but the last named wood, although extremely strong and pliable, lacks the elasticity of greenheart. Black chuglam, on the other hand, has been reported on as very satisfactory. *Homalium tomentosum* and *Caryota urens* have also been tried successfully, but the former is apt to develop fine hair cracks, and neither can compare favourably with greenheart.

Bamboos are used on a large scale for fishing rods in India, the well known *ringal* (*Arundinaria falcata*) being amongst the most popular. The so-called split-cane rods are usually made of split bamboo. The bamboo now used for this purpose is a Chinese bamboo called *palankona,* which is very strong and has a very hard surface and small nodes. The exact species of this bamboo is not known. The 'male' bamboo (*Dendrocalamus strictus*) was at one time used for split-cane rods, but owing to deterioration in the quality of the supplies sent to

Europe, the export from India dwindled, and has now been almost completely taken over by China and Japan.

Golf clubs

For many years, golf club manufacturers have been searching for a substitute for hickory (*Hicoria* sp.) for golf club shafts, but to date no substitute has been found, unless it is the steel shaft now becoming so popular. Hickory is a native of South America, and possesses certain qualities which are difficult to find amongst other woods. The chief of these are its great strength, combined with toughness and elasticity. Other timbers can be found which approach hickory in some respects, but none of them come up to it in all qualities combined. Ash (*Fraxinus* species) is also used for golf club shafts but is not considered to be of the same quality as hickory. Several Indian woods have been tried at one time and another for this purpose, and some approach hickory very closely, and in any case make perfectly good shafts for the average player.

Of these, *Terminalia manii* (black chuglam), *Sageraea elliptica* (chooi), *Grewia* species, *Anogeissus* species, and *Lagerstroemia hypoleuca* (jarul) are the best, and have all been tried and tested by experienced players and have been in use for years without deterioration. For golf club heads, *Xylia dolabriformis* (*pyinkado*), *Mesua ferrea* (mesua), *Pterocarpus macrocarpus* (Burma padauk), *Acacia arabica* (babul), and *Carapa moluccensis* (pussur) have all been tried and found suitable. Babul was approved by a large European firm and pussur has been used in Australia.

Guns and rifles

The wood used for gun and rifle parts, which include the stock, fore-end and hand guards, must be *moderately hard, close-grained, perfectly sound, and of a weight of about* 35 *lb. per cu. ft.* but above all it *must stand up to the high-speed machines* used in the manufacturing process, and *must not under any circumstances split, warp or 'move' in service.* This last consideration can only be achieved by perfect seasoning, and gun makers usually store their stocks of wood for three or more years before use. Many woods have been tried for this work, but so far only walnut (*Juglans regia* and *Juglans nigra*) has been found really suitable for high class sporting gun work and army rifles. Walnut appears to be an ideal wood for the purpose, as once it is properly seasoned it is an exceptionally 'steady' wood, and does not 'move' or warp in the slightest degree, even under extreme changes of temperature and climate. In addition, its weight is correct and it has the added advantage of having a fine grain, which for high grade sporting weapons is a valuable asset. Very big prices are paid by gun makers for fine coloured wavy and figured walnut.

In India, the manufacture of high grade sporting guns and rifles is not extensive, and such walnut as is used for the purpose is usually imported, but the manufacture of army rifles is carried out on a large scale in the Ordnance Rifle Factory at Ishapore, near Calcutta. The wood used for this purpose is again walnut, and supplies are obtained partly from North India (Kashmir and North-West Frontier Province) and partly from abroad.

Supplies of walnut in India are limited. The tree is very slow-growing, and most of the older trees have already been extracted. The result is that the walnut supplies of the present day are not up to the same standard as they were some years back. Nevertheless several thousand sets of walnut half-wroughts are sent to Ishapore every year from Kashmir.

Other timbers have been tried from time to time as substitutes for walnut for army rifle work, but for one reason or another a really suitable substitute has not yet been found.[1] Some of the woods tried were *Tectona grandis* (too heavy and too brittle), *Artocarpus hirsuta* (blunts machine knives), *Pterocarpus marsupium* (too heavy), *Adina cordifolia* (too brittle and bad colour), *Albizzia lebbek* (too heavy and too weak).

For cheaper types of 'country-made' guns and rifles, timbers other than walnut are used, but although some are fairly satisfactory, others can be said to be definitely unsuitable. Troup records a long list of woods used for this purpose, of which the following are probably the best, *Adina cordifolia, Cordia myxa, Dalbergia latifolia, Dalbergia sissoo, Gmelina arborea, Lagerstroemia flos-reginae, Morus serrata, Pistacia integerrima, Taxus baccata, Tectona grandis.*

Artocarpus hirsuta, Albizzia lebbek, and *Pterocarpus marsupium* would probably be better than any of the above.

Hockey sticks

Hockey sticks in Western countries are made of ash (*Fraxinus excelsior* and others), and most of the sticks imported into India will be found to be made of this wood.

In India, ash is not very common. It is true that *Fraxinus excelsior* grows in India, and that the country possesses other representatives of the family in *Fraxinus floribunda* and *Fraxinus micrantha*, but none is really common, and they only grow at high elevations which makes their extraction both difficult and expensive. Substitutes have therefore been sought, and mulberry (*Morus alba*) has been found extremely suitable for the purpose, and is now used as the chief hockey-stick wood in India. During the last few years mulberry hockey

[1] Indian maple and bird cherry have recently been accepted for army rifle work. Supplies are, however, limited (1939).

sticks have been exported in large quantities to Europe and elsewhere, and the opinion is growing that Indian mulberry from Changa Manga plantation makes a better stick than ash. Other woods such as sissoo (*Dalbergia sissoo*) are also employed for the purpose, but this is due to their being common timbers in North India, where the chief centres of manufacture are, rather than to their inherent properties for the purpose in view. Hockey sticks are usually steam-bent, and besides having the necessary qualities of toughness, hardness, and elasticity must be made of a wood with straight grain which will stand up to the process of bending without cracking and splitting.

Mulberry has proved to be an excellent wood for steam bending and has all the qualities demanded. It is not surprising therefore that of late years the export of Indian mulberry hockey sticks to Northern Europe has increased considerably, and reports received from European firms indicate that it is now preferred by many to the European ash stick. *Celtis australis* from Kashmir is another wood used for hockey sticks in Northern India.

Lance and spear shafts

Lance and spear shafts are usually made of bamboo, the solid 'male' bamboo (*Dendrocalamus strictus*) being that used for the purpose. Shafts have to be very carefully selected, and any bamboo showing a flaw or damage by borers or not coming up to standard in the matter of size is at once rejected. Those selected are then subjected to severe treatment in the matter of seasoning, straightening, and preparation generally for the purpose in view.

Skis

Skis are a fairly modern importation into India and it is only a few years ago that ski-ing in this country was seriously considered. The sport has, however, caught on, and there is now a Ski Club in North India. A demand for suitable woods for the manufacture of skis has, therefore, sprung up, but as yet is still small.

The woods used in Western countries are ash (*Fraxinus* species) and hickory (*Hicoria* species). Indian ash (*Fraxinus floribunda*) has been tried and found suitable, but both *Dalbergia sissoo* (sissoo) and *Anogeissus latifolia* (axle-wood) were reported on as better than Indian ash by the Honorary Secretary of the Ski Club of India. *Toughness, flexibility, even texture,* and *straight grain* are the essential features for a good ski wood.

Tennis racquets

In Western countries, the frames of tennis racquets are usually made of ash (*Fraxinus* species), and this timber has been used with success in India, but,

as already mentioned, ash is not very common or easily available in India and substitutes have to be sought.

Dalbergia sissoo (sissoo), *Juglans regia* (walnut), and *Morus alba* (mulberry) have all been used with success, the last named being especially popular for frames, while the other two are employed for the wedge and handle pieces. It must be remembered that tennis racquet frames have to be steam-bent, and a *long-fibred* and *straight-grained* wood is therefore essential. *Morus alba* fulfils both essentials. Many other woods have been tried, and in fact are used in small quantities for the wedge and handle parts; *Cedrela toona, Swietenia mahogani, Swietenia macrophylla,* and *Melia azedarach* being amongst the best for the purpose.

Miscellaneous Uses

Agricultural implements

'Agricultural implements' is a comprehensive term with a wide application, but when using it, reference to such appliances as ploughs, harrows, rollers, and clod-crushers is usually understood. In India, these implements are, more often than not, made entirely of wood, and the amount of timber used for their construction is quite considerable.

Only the strongest, toughest, and hardest woods are any use for such work, and the local wood which complies best with these essentials is the one usually selected. The following woods are (according to Troup) all used for the purpose:—

> *Acacia arabica, Acacia catechu, Anogeissus latifolia, Cassia fistula, Chloroxylon swietenia, Dalbergia sissoo, Diospyros melanoxylon, Mesua ferrea, Ougeinia dalbergioides, Prosopis spicigera, Pterocarpus* species, *Quercus* species, *Schleichera trijuga, Shorea robusta, Tectona grandis, Xylia* species, and *Zizyphus jujuba.*

For ploughshares and harrow teeth only the hardest and toughest woods available should be used.

Bearings, brushes, and rollers

Only the hardest woods are any use for this type of work. That most commonly used is *lignum vitae* (*Guaiacum officinale*), a wood of tropical America, and one which is only found in very small quantities in India as a planted tree in Calcutta and Madras. There are, however, Indian substitutes for *lignum vitae,* of which the following are perhaps the best:—

> *Acacia arabica, Diospyros burmanica, Heterophragma adenophyllum, Hopea parviflora, Mesua ferrea, Pterocarpus macrocarpus, Xylia dolabriformis,* and *Xylia xylocarpa.*

Bentwood articles

Mention has already been made, under the subjects of various articles such as hockey sticks and tennis racquets, of the bending of wood by steam. The application of heat and moisture to wood renders it extremely pliable, so that small scantlings and planks can be bent to any desired curve as if they were formed of homogeneous material. This intrinsic characteristic of wood is taken advantage of in various trades, and bentwood articles are now a common feature in furniture, wheelwright, ship-building, and other industries. Steam-bending may be done in various ways, but the principle is the same in all cases. The wood is placed in a closed chamber into which steam is introduced. After a varying period of steaming, which must be sufficient to allow the wood to become thoroughly saturated, the timber is removed and placed on a fixed frame over which it is bent and clamped in the desired form and left to cool and dry. Sometimes it is not possible to obtain the desired curve at once, and the wood has to be gently forced by increases of pressure, or re-steamed and bent a second time to a curve which it was not possible to obtain by one application.

The chief danger in steam-bending is the splitting of the fibres on the convex side, either during the process of bending, or when the wood is drying out and consequently shrinking.

Some woods bend more easily than others, and those with long straight fibres are usually better for the purpose than those with short grain. If the fibres are not straight and run across the length of the piece to be bent, warping and twisting is apt to result. Large knots should also be avoided, as bent wood is very liable to split at a knot, due to the interruption of the straight run of the fibres.

Steam-bending is not practised a great deal in India, except in the manufacture of sporting goods such as tennis racquets and hockey sticks. Bentwood furniture, which is a thriving industry in Europe and America, is almost an unknown trade in India, and even the steam-bending of ribs and planks for boats, and felloes for wheels, is only practised on a very limited scale. Information on the steam-bending qualities of Indian woods is therefore scanty. The following woods are, however, known to bend well: *Dalbergia* species, *Morus* species, *Fraxinus* species, *Pterocarpus* species, *Cedrela* species, and the conifers *Cedrus deodara*, *Abies pindrow*, *Picea morinda*, *Pinus longifolia*, *Pinus excelsa*, and *Cupressus torulosa*.

On the other hand, *Albizzia lebbek*, *Terminalia tomentosa*, *Chloroxylon swietenia*, and *Adina cordifolia* are not good bending woods.

In some cases, *green* wood can be bent as easily as steamed wood, and this fact is taken advantage of in the manufacture of walking sticks and umbrella handles, plaited wooden baskets, sieve frames, and drums for fruit and dry

goods. For these goods, the wood is usually split whilst still green, plaited or bent to the required form, and allowed to dry. In other cases, small coppice shoots of fast-growing species are used for similar work, and especially for plaiting into baskets and fish traps. The species chiefly used for these operations in Western countries are osiers, i.e. one-year shoots of willow (*Salix* species), but in India split bamboos are most commonly used for this type of work.

Bobbins, picker arms, shuttles, etc.

'Bobbins' is often used as a comprehensive term to describe the great variety of articles used in the manufacture of cotton, jute, and woollen goods, such as tubes, pirns, spools, and reels.

Picker arms and shuttles have to perform somewhat different functions from the above articles and require special qualities.

The chief requisites of a good **bobbin** wood are that it shall be *close-textured, of medium weight* (about 40–45 lb. per cu. ft.), and *sufficiently strong to stand up, not only to the work required of it, but to the strains set up on the high-speed machines used in its manufacture.* It should also finish to a clean surface and not chip or ruck up under the action of turning machines.

The majority of bobbins used in India are imported from Europe and Japan. The European bobbins are usually made of beech (*Fagus* species), and those from Japan of maple, pear and other woods. There is one fairly large bobbin factory at Clutterbuckganj, near Bareilly in the United Provinces. The chief wood used is haldu (*Adina cordifolia*) but supplies are limited. This factory also uses kaim (*Mitragyna parvifolia*), kanju (*Holoptelea integrifolia*), and kuthan (*Hymenodictyon excelsum*). Other timbers recommended for bobbins are *Sonneratia apetala, Saccopetalum tomentosum, Wrightia* species and *Lagerstroemia flos-reginae.*

Picker arms do not have to undergo the same strenuous treatment as bobbins during manufacture, and there is no reason why several Indian woods should not be suitable for this purpose. At present, picker arms are being made only on a limited scale in India, but *Anogeissus latifolia, Ougeinia dalbergioides,* and *Grewia tiliaefolia* have all been used with success and reported on as satisfactory by cotton mills.

For **shuttles** a *hard, close-grained, tough, strong wood* is required. Some of the timbers recommended for this purpose are *Diospyros melanoxylon, Gardenia latifolia, Saccopetalum tomentosum, Ougeinia dalbergioides, Acacia arabica, Thespesia populnea* and *Lagerstroemia lanceolata.* Shuttle manufacture is only just starting in India, but there are already three shuttle factories at work in Bombay. Imported shuttles, which still comprise the

bulk of the shuttles used in India, are usually made of cornel or persimmon wood.

Boot lasts and trees and wooden shoes

For this work, a *fine-textured, medium-weight, and moderately hard wood is required*, and a further essential is that the wood should be *one which does not crack and warp, and keeps its shape indefinitely. It should also be a wood which cuts easily* so that it can be shaped to the desired form without undue labour. Such timbers as *Adina cordifolia, Holoptelea integrifolia, Mitragyna diversifolia, Gmelina arborea, Holarrhena antidysenterica*, and *Rhododendron* species would make good boot and shoe lasts, while *Buxus sempervirens, Adina cordifolia, Mesua ferrea, Pterocarpus* species, *Acacia arabica*, and *Xylia* species would make good boot trees.

Wooden shoes are not used in India to the same extent as they are in some parts of Europe. In France, for example, no less than 600,000 pairs are produced annually in one district alone. Wooden soles are, however, a common feature in some parts of India and especially in Burma, where they are made of *Croton oblongifolius, Gmelina arborea*, and *Stephegyne diversifolia*.

Brushes and brooms

There are many different kinds of brushes, varying from the high class toilet and hair brush to the paint brush and household brushes of different descriptions. Brooms also range from the light household variety to the heavier drain-cleaning and road-sweeping types.

Generally speaking, the wood used for brushes must be of *medium hardness, close-textured, free from knots, and not liable to split or crack.* For toilet and hair brush backs, good grain and colour is a desirable feature. Such woods as *Diospyros ebenum, Chloroxylon swietenia, Carallia integerrima, Dalbergia* species, and *Pterocarpus* species are used for this purpose, while *Cedrela toona, Adina cordifolia*, and *Holoptelea integrifolia* are used for the backs of cheaper brushes.

Brushes and brooms are made in several places in India, and there is a large factory manufacturing these articles on an extensive scale in Cawnpore. This factory reports that *Millingtonia hortensis, Hymenodictyon excelsum*, and *Cedrus deodara* are the woods they find best for ordinary household brooms and brushes, while *Mangifera indica* is used for rougher types of brushes for drain-cleaning and road-sweeping. *Mitragyna parvifolia* is said to be excellent for paint brush and shaving brush handles, while *Odina wodier* has been used for army horse brushes. On the other hand, *Adina cordifolia* is said to split too much for broom work, while *Dalbergia sissoo* is too hard and of a bad colour, and there is a big loss in conversion when handling this wood. *Odina wodier* is also reputed to

be expensive in conversion owing to excessive sapwood, and is therefore not used for brooms.

Carving, toys, combs, etc.

For cheap painted toys, most light, easily worked woods are suitable, but for carved ornaments and toys, and for carving generally, a *fine-, close-, and even-textured wood is essential. It should also be free from knots and other defects, and should not be liable to split*, thereby spoiling the general effect of the carving. Green wood is often used for carving as it is easy to cut in this condition, but the practice often results in seasoning defects developing later and spoiling the article in question. It is better to do all carving work on thoroughly seasoned wood of a suitable kind. The wood selected depends on the finished article. For toys, bowls, wooden spoons and such articles, a plain uncoloured wood selected for its carving qualities is usually preferred, whereas for ornamental carvings colour and grain may be an important feature.

For the former type of article, such woods as *Adina cordifolia*, *Holarrhena antidysenterica*, *Boehmeria rugulosa*, *Wrightia tinctoria*, and *Wrightia tomentosa* are already well known in India as excellent carving woods, while *Michelia excelsa*, *Michelia champaca*, *Gmelina arborea*, *Mitragyna* species, *Phoebe hainesiana*, *Tectona grandis*, and some of the finer conifers such as *Cedrus deodara* and *Cupressus torulosa* are also used.

For better class work, *Santalum album* holds premier place, and the well-known sandal wood carvings of Mysore find a ready market the world over on account of the pleasant perfume and the close smooth texture of the wood. Box (*Buxus sempervirens*) is rather too hard for carving, and the same may be said of red sanders (*Pterocarpus santalinus*), though the last named is used for the purpose in Madras. Teak is used extensively in Burma and carved teak elephants and other figures are sold in large quantities in Rangoon and elsewhere, while walnut (*Juglans regia*) is a popular carving wood in Kashmir, and the carved walnut screens, furniture, and trays from that State are well-known features in Indian and European markets.

Indian combs, such as those used by Sikhs in their hair, and by Burmese ladies for a similar purpose, are an important industry in India. The best quality combs are made of box (*Buxus sempervirens*), haldu (*Adina cordifolia*), and sandal wood (*Santalum album*), while cheaper combs are found in the woods of *Aegle marmelos*, *Carissa* species, *Crataeva religiosa*, *Dalbergia* species, *Diospyros* species, *Gardenia* species, *Gmelina arborea*, *Holarrhena antidysenterica*, *Holoptelea integrifolia*, *Olea ferruginea*, *Mitragyna parvifolia*, and *Wrightia* species.

Other woods not mentioned above but used locally for carving work and combs are *Aesculus indica*, *Alstonia scholaris*, *Boswellia serrata*, *Cedrela toona*,

Celtis australis, *Givotia rottleriformis*, *Melia indica*, *Pistacia integerrima*, *Pterocarpus* species, and *Tecoma undulata*.

Cigar boxes

For cigar boxes, the wood of the West Indian cedar (*Cedrela odorata*) is the best known, as it has a pleasant perfume which does not taint cigars, while other woods will often do so. This wood is, therefore, the chief cigar-box wood of Europe and America, but the species is not found in India except as a planted tree. Other *Cedrela* species are, however, equally suitable for the purpose, and in India *Cedrela toona*, *Cedrela microcarpa*, *Cedrela multijuga*, and *Cedrela serrata* are all used. In South India, very large quantities of *Cedrela toona* are consumed by the cigar industry. *Melia azedarach* and *Melia composita*, which are of the same Natural Order (*Meliaceae*), are also largely used for this purpose. Other woods have been tried, such as haldu (*Adina cordifolia*), but they are not really suitable.

Engraving

The wood used for engraving, i.e. for the blocks for wood-cuts in printing, must be *very close- and even-textured*, so that it will not absorb inks and colours unevenly or too freely. It must also be *very hard* so that the sharp edges carved on it will not get abrased by the pressure to which it is subjected in the press. Box (*Buxus sempervirens*) is superior to all other woods for engraving, though for rough wood-cuts other even-grained woods can be used. *Mitragyna diversifolia* has been used in Burma, where imported box and birch were previously used, and the latest report is that this wood has definitely ousted imported timbers for this work.

Other substitutes for box for engraving are *Gardenia latifolia*, *Gardenia turgida*, *Randia dumetorum*, and *Olea ferruginea*, while for some classes of work *Wrightia tinctoria*, *Wrightia tomentosa*, *Holarrhena antidysenterica*, and *Adina cordifolia* might be suitable.

In Bombay and Sind, carved dies for stamping coloured patterns on cloth are made of *Acacia arabica*.

Figure cutting

For making models or figures for cast metalwork, a high quality wood is required. The main essential is that *the wood should not alter its shape*, as this would at once make the resultant casting of little use. A certain amount of shrinkage is inevitable, and this is allowed for in making the model, but any wood that is liable to excessive cracking and warping should not be employed for this

work. Another desirable quality is that *the wood should cut cleanly and easily* so that an accurate model can be made, a highly desirable feature when casting intricate cog-wheels and other machinery parts. Coniferous woods are the most favoured for this work, and in India *Cupressus torulosa* is the best. Clear deodar (*Cedrus deodara*) wood, i.e. wood free of knots and excessive oil, is also used. Hardwoods are also often employed for this work, *Adina cordifolia* being the one most often selected. Teak is used for the purpose in Burma.

Mathematical and draughtsman's instruments

The best quality instruments are usually made of box (*Buxus sempervirens*), while scales and foot-rules of a cheaper type are made of such woods as haldu (*Adina cordifolia*), *Gardenia* species, and *Holoptelea integrifolia*. Ebony (*Diospyros ebenum* and *Diospyros melanoxylon*) is often used for this work, especially for facing T-squares and set-squares, and for round rulers. A firm in Lahore tried several Indian woods for cheap school rulers and set-squares and found that clean silver fir and cypress answered the purpose well, while *Aesculus indica* and *Pyrus* species were equally good but difficult to obtain.

There is no great difficulty about woods for this kind of work. The chief requisites are a *close fine texture and non-liability to crack and warp*. Experimental instruments have been made at Dehra Dun with a variety of woods, including *Pentace burmanica, Bursera serrata, Pterocarpus dalbergioides,* and *Dalbergia latifolia*, and they have been found to answer the purpose quite well, provided they are well-seasoned.

Musical instruments

For the sounding-boards of stringed instruments and pianos, wood of a regular structure and without flaws of any kind is essential. The wood of conifers is considered the best, and spruce is usually selected. Silver fir is sometimes, but more rarely, employed. The simple anatomical structure of spruce wood, the absence of vessels, the extremely fine evenly distributed medullary rays, and the straight and long-fibred nature of the wood, make it a timber *par excellence* for reverberating pure tones. The best wood for musical instruments is that having uniform annual zones of from 1·5 to 2 mm. and summer wood of $\frac{1}{4}$ to $\frac{1}{5}$ of the zone. The wood should also contain no knots or flaws of any kind and as little resin as possible, and its weight should be as low as possible, 25 lb. per cu. ft. being the ideal.

For piano-cases, ornamental woods such as mahogany, walnut, satinwood, Andaman padauk, and figured laurel are used, while the sides and backs of violins are usually made of maple. In India, teak is often used for the bodies of pianos, organs, and harmoniums, while Himalayan spruce, blue pine, and chir pine are used for the bodies of violins. Indian maple (*Acer* species) is used for

violin bridges, teak and ebony for keys, and sundri (*Heritiera minor*) for bows. The Indian *sitar* and similar instruments are made of teak, *Cedrela toona, Juglans regia, Gmelina arborea*, and *Morus* species, while *Cedrus deodara* and *Dalbergia sissoo* are used for the keys. The bodies of banjos are also made of teak, and Burmese harps of *Pterocarpus macrocarpus*. Drums and tom-toms are made of various woods, the best-known being Indian ash (*Fraxinus* species), mulberry (*Morus* spp.), and *Dalbergia sissoo*. *Adina cordifolia, Albizzia stipulata, Artocarpus integrifolia, Bassia latifolia, Bombax malabaricum, Garuga pinnata, Gmelina arborea, Melia indica, Odina wodier, Pterocarpus marsupium, Sapium insigne*, and *Trewia nudiflora* are (according to Troup) also used.

An inquiry from Europe for woods for xylophone keys resulted in *Dalbergia oliveri, Dalbergia latifolia*, and *Pistacia integerrima* being tried. The last named proved the best of the three.

Pencils and penholders

Wood for pencils has to have special qualifications, the most important of which is that *it must cut easily and smoothly*. This does not sound a very difficult feature to obtain, but in practice very few woods have the smoothness of cut essential for pencil making, combined with a *fine even texture and correct weight*. Pencil woods must also be *straight-grained and free from knots and other defects*.

The best wood for the purpose is the so-called pencil cedar (*Juniperus virgiana* and others) found in the United States, Canada, and West Indies. A similar wood (*Juniperus procera*) also grows in East Africa.

Many woods have been tried from time to time in India, but except for *Juniperus macropoda* and *Juniperus recurva*, neither of which is easily exploitable, it is doubtful if there is an Indian wood which can be said to be of the same quality as pencil cedar.

Cupressus torulosa is probably the next best substitute, with *Pinus excelsa* as second choice. Both these woods are being used in a large pencil factory at Agra, which, nevertheless, still imports a great part of its wood from East Africa.

Cedrus deodara, Podocarpus neriifolia, Pinus longifolia, Wrightia tomentosa, Cedrela toona, Kydia calycina, and *Mitragyna parvifolia* have all been tried and actually made into pencils, but the woods were too tough and not really suitable.

For penholders, not nearly such severe qualifications are necessary as for pencils, and provided a wood has a *fine even texture, is straight-grained and free from defects*, it will probably be suitable for making into penholders. All the woods mentioned under pencils above are suitable, and *Taxus baccata* also is said to make a good penholder, while other woods such as *Abies pindrow, Picea morinda, Michelia* species, and *Gmelina arborea* would probably do well.

Picture frames

Frames for pictures are either made of wood in its natural state or of wood covered with a coating of plaster of Paris and finished with paint, varnish, or gilt.

The wood required for the former type of frame should be ornamental, whereas the appearance of the wood used in the latter type is immaterial. Other qualifications are the same in both cases, namely *straight grain, and non-liability to warp, with an aptitude for taking a clean cut.* The last consideration is necessary not only for getting a good corner joint, but also because most frames are cut into a mould, the edges of which should be clean and true if the framing is to have a good appearance.

Most of the better class cabinet woods such as *Dalbergia* species, *Albizzia* species, *Pterocarpus* species, and *Tectona grandis* make excellent natural wood framings, while cheaper woods such as *Cupressus torulosa*, *Abies pindrow*, *Picea morinda*, *Cedrela toona*, *Chukrasia tabularis*, *Phoebe hainesiana*, *Morus* species, *Mitragyna* species, and even soft woods like *Bombax insigne*, *Hymenodictyon excelsum*, and *Trewia nudiflora* are quite suitable for painted and gilded framing. *Cedrela toona* is often used for making carved frames in Northern India, and *Juglans regia* is used for the same purpose in Kashmir. Carved frames of sandal wood (*Santalum album*) are also commonly seen in Mysore and South India.

Sticks, umbrella handles, and police batons

Walking-sticks are made from a large variety of woods, some on account of their ornamental appearance and others on account of their straightness and strength. The latter is by far the commonest type, and as sticks are used almost universally in hilly country even by the poorest peasant, stick-making is a common trade in the hill districts of India. It is not surprising therefore that many Himalayan species are well-known as producing good walking-stick woods. Amongst the species most used for this purpose are *Cotoneaster bacillaris*, *Cotoneaster acuminata*, *Prunus puddum*, *Pyrus pashia*, *Quercus* sp., *Crataegus* sp., *Parrotia jacquemontiana*, *Xanthoxylum alatum*, *Caryopteris wallichiana*, *Fraxinus floribunda*, and *Celtis australis*. In Burma, *Heterophragma adenophyllum* and *Canthium didymum* are popular for strong sticks.

In the plains, more ornamental woods are used such as *Dalbergia latifolia*, *Dalbergia sissoo*, *Albizzia* species, and the ebonies (*Diospyros* species), while very decorative walking-sticks are made of *Diospyros marmorata*, *Olea ferruginea*, and *Santalum album*, which is often carved for the purpose.

Bamboos and canes are also used extensively for walking-sticks and *lathis*. The best canes for the purpose are *Calamus viminalis* (the rattan), *Calamus latifolius*, and *Calamus acanthospathus*. Several palms furnish handsome sticks,

the well-known 'porcupine wood' from the coconut palm (*Cocos nucifera*) being a good example. The hard outer wood of *Borassus flabellifer* and *Caryota urens* are of the same type.

Umbrella handles are now made in a variety of shapes and sizes. For natural handles most of the woods mentioned under walking-sticks are suitable, while small bamboos are in keen demand for steam-bent handles for the cheap 'country' umbrella so common in India. Imported steam-bent handles are usually found to be of *Juniperus* sp. These handles mostly come from Japan and China. There is also a very good market for bamboo handles in Europe, and the question as to which were the best bamboos for the purpose was investigated by the Forest Research Institute when it became known that the European market was fed almost entirely by bamboos known as *tsinglees* from China. The Indian bamboos found suitable and approved by the trade as the result of this inquiry were *Pseudostachyum polymorphum* and *tiyowa* (species unknown, the Burmese umbrella bamboo) from Assam and Burma respectively. *Oxytenanthera monostigma* from Bombay and two *Arundinaria* species (*Arundinaria jaunsarensis* and *Arundinaria falconeri*) from the United Provinces were also approved. *Pterospermum acerifolium* is a wood which was tried for umbrella handles in Bareilly and reported on favourably.

For **police batons,** a very heavy strong wood is required. The police batons used by the London metropolitan police are made of a species of *Millettia*, possibly *Millettia pendula* from Burma. An excellent baton is made from *Olea ferruginea*, this wood being one of the heaviest and strongest in India. It also finishes to a fine smooth surface and does not split.

Other woods suitable for the purpose are *Heritiera minor*, *Cotoneaster bacillaris*, *Mesua ferrea*, *Pterocarpus macrocarpus*, *Xylia dolabriformis*, and possibly *Berrya ammonilla*.

Tobacco pipes

The well known 'briar' pipes are made from the roots of a large heath (*Erica arborea*) which grows chiefly in the south of France. This shrub is not found in India, nor is there anything closely resembling it. The wood for a pipe must be of rather exceptional character, as it has to withstand the heat of the burning tobacco without sweating or cracking. Several Indian stem woods and root woods have been tried for the purpose, but none has proved suitable, and it is very doubtful whether a really good pipe wood will be found in this country. Dry knots cut out of teak wood are used in Burma and make a fair pipe, while bamboo nodes are also employed to make cheap pipes.

Indian 'country' pipes and hookahs are made from a variety of woods, and Troup mentions *Amoora cucullata* (for hookah-stems in the Sunderbans),

Boswellia serrata (Merwara), *Dalbergia sissoo, Juglans regia, Mesua ferrea, Phyllanthus emblica,* and *Pyrus pashia* as being among the most common. It is a pity that no Indian wood can be found to take the place of the root wood of *Erica arborea,* as tobacco pipes are a potential market, and one factory in France spends £100,000 per annum on buying this wood, and is prepared to pay Rs16 to Rs18 per cubic foot solid for a suitable substitute.

Turnery

Woods for turnery may be divided into two classes, namely those woods used for domestic utensils such as milk jars, cups, bowls, etc., and those used for the finer articles of ornamental turnery such as legs for furniture and candlesticks. Woods for the first class are usually pale-coloured or white woods of even and fine texture, while those for the second class are more often coloured and ornamental. Timbers of the first class are *Adina cordifolia, Boehmeria rugulosa, Holarrhena antidysenterica, Wrightia tinctoria* and *Wrightia tomentosa, Aesculus indica, Acer* species, *Crataeva religiosa, Mitragyna parvifolia,* and *Tamarindus indica,* while examples of the second class are *Acacia* species, *Buxus sempervirens, Carapa moluccensis, Cassia fistula, Chloroxylon swietenia, Dalbergia* species, *Diospyros* species, *Melannorrhoea usitata, Olea ferruginea, Pistacia integerrima, Pterocarpus* species, *Santalum album, Tectona grandis,* and *Zizyphus jujuba.* In Burma the best turnery woods are *Millettia pendula, Cassia siamea, Dalbergia oliveri,* and *Dalbergia cultrata.*

Firewood

Firewood plays a more important part in a country like India than it does in other countries where coal is consumed more extensively. In some parts of India it is an economic necessity, while in others it does not play such an important part. For example, in arid regions where tree growth is scanty and coal not available, the presence of one good fuel wood is a matter of serious moment to the inhabitants. Thus, in the drier parts of the Punjab and elsewhere, the presence of *Prosopis spicigera* is a providential gift of Nature, and both the people and local industries would be hard put to it to find a substitute. It is a good fuel wood and the only wood there is in some districts, where it is used by large mills and on river steamers as the sole source of fuel. In such areas fuel becomes a major revenue-producing forest product, whereas in well-wooded districts the sale of wood for fuel is often only of secondary importance. Generally speaking, hardwoods are better fuel woods than softwoods. They give out a more lasting and uniform heat and are therefore preferred for household purposes, but for baking and roasting, where a quick intense heat is required, softwoods (conifers) are often preferred. In industrial circles hardwoods are

always preferred and especially in soap factories, laundries, and all other mills where boilers are employed, but in bakeries, potteries, brick-making, lime-burning, and similar industries where a quickly radiating intense heat is wanted, softwoods are preferred. It is not always possible, however, to obtain the best wood for each individual purpose, and in practice the cheapest available fuel wood is generally the one used.

In those districts where firewood is an important forest product, well-organized fuel depots are usually to be found. In other localities, and this is the more common practice in the greater part of India, firewood is cut, extracted, and sold by the timber contractors who are working the coupes, and is regarded by them as a source of extra profit. In some cases, they sublet the right to cut fuel wood, from the lop and top of the major fellings, to petty contractors, who extract it in carts or on animals and sell it locally.

The different forms of firewood seen in India are (1) split wood, (2) round billets, and (3) dead wood collected from the ground. In some localities root and stump wood is also extracted as fuel. The actual sizes of split wood and round billets vary considerably, but as firewood is usually sold retail by weight in India, the size of the pieces is not important and generally conforms to the requirements of the local demand. In large fuel depots firewood is usually sold by stacks of uniform size, and if stacking is well done the cubical content and weight keep a very close average over a large number of stacks.

Split wood dries much quicker than round wood, and experiments in Europe show that split wood loses 27 per cent more weight in 5 months than unsplit wood, and that its loss in weight in one month is double that of round wood of the same material. The rate of drying naturally depends on many conditions, such as climate, species, and size, but speaking in general terms split firewood will always dry quicker than unsplit timber of the same dimensions.

In addition, it must be remembered that dry wood burns better and gives out more heat than wet wood, so the importance of getting firewood to dry as quickly as possible is from that point of view a matter of importance.

It is not necessary to discuss again here the value of different woods as fuel, as this subject has been fully dealt with in Chapter I, and full lists of good and bad fuel woods, and of the calorific values of Indian timbers, will be found on pages 36–8.

Pulpwood

The extraction of wood from the forests of India for making into pulp for paper manufacture and allied trades has never been carried out on a large scale in this country. The staple raw materials for pulp making in India are at present indigenous grasses and bamboos and imported wood-pulp. On account of the great difficulties of obtaining in sufficient quantities and extracting

suitable woods at competitive prices, there is no likelihood of imported wood-pulp being supplanted by Indian wood-pulp for some years to come, but the matter has not been lost sight of and it is possible that with cheap electric power it may yet be possible to use Indian woods for pulp manufacture, more especially for mechanical pulp manufacture.

Hand-made paper manufactured from wood has been known for many years in India, and especially in Kashmir, but this small local trade can scarcely be compared with the large modern paper mills of today. In Europe and America the situation is very different, and wood is the chief raw material of pulp mills. In 1931, the world's total consumption of paper and boards was estimated to be 20 million tons, of which about 80 per cent was produced from wood. India's contribution to the world's total is only 40,000 tons per annum, of which about 25 per cent is made from grass, 35 per cent from bamboos, and the remainder from imported wood-pulp and other materials such as rags and straw.

There are two main classes of wood-pulp used in paper mills, namely mechanical wood-pulp and chemical wood-pulp. The former is made by wood being ground to pulp by means of revolving grindstones being pressed against it, while the latter is the result of chemical action, which reduces the wood to pure cellulose by extracting all extraneous substances. Mechanical pulp contains all the constituents and elements of true wood, but it does not possess 'felting' power, i.e. the property of interweaving and interlacing into a felted fabric, in the same degree as chemical pulp, which consists of pure cellulose fibres specially adapted for gripping and interlacing with other fibres to form a strong felted mass. Mechanical pulp is, therefore, of inferior value to chemical pulp, and cannot by itself make a good paper. It is however cheaper to manufacture than chemical pulp, and finds its chief use in newspaper, which is not required to be a durable or strong type of paper.

Chemical pulp on the other hand is strong and durable, as the individual wood fibres have been separated from extraneous substances by chemical action and are free to weave themselves into a solid felted mass when shaken in water which is afterwards drained or squeezed away. Finally, the combining of mechanical and chemical pulps is a common practice and is adopted in all but the cheapest types of newsprints. The woods most in favour for wood-pulp are such white soft woods as aspen and poplar (*Populus* species) and limes (*Tilia* species), but as these timbers are quite insufficient to meet a fraction of the demand, recourse is had to the conifers, and chiefly to spruce (*Picea* species), which is very soft and has a good colour and good length of fibre. In India, *Picea morinda* has been shown to possess a greater length of fibre than any of the European and American species of *Picea*, and it was this species which was utilized in Kashmir for paper manufacture in small 'country' mills. The industry

was fairly prosperous before the advent of the large up-to-date pulp and paper mills in India, but since their arrival it has dwindled and is now practically extinct. There is no reason why wood-pulp should not be manufactured on a large scale in India, provided cheap water-power is made available and the mill is placed where the wood can be delivered cheaply, but with such excellent paper-making materials as grass and bamboo in abundance at cheap rates, there is no great inducement at present to look for other raw materials, more especially while the price of imported wood-pulp remains so low. Attempts have been made from time to time to stimulate interest in pulp production from Indian conifers, and even from hardwoods such as *Eucalyptus globulus* in South India, but for one reason or another interest has not been maintained, and unless conditions alter radically in the future the manufacture of pulp from Indian woods is not likely to develop on a large scale for some years to come.

Wastewood

The term 'wastewood' is really a misnomer, since waste is defined as no longer serving a purpose, whereas wastewood often serves a very useful purpose and not infrequently produces a handsome return. The three main products usually classified under wastewood are (1) sawdust, (2) shavings, and (3) wood wool, and the subject will be dealt with under these heads.

Sawdust

At one time sawdust was looked upon as pure waste, but during the last half-century, the ingenuity of mankind has devised many uses for it, and it is now looked upon in up-to-date mills as no longer a waste product, but one which is capable of adding considerably to the profits of the mill.

In the first place, it can be used with advantage as a fuel in boiler furnaces, but only when special arrangements are made to see that there is plenty of air or 'draught' to ensure its burning. Sawdust in the ordinary way does not burn easily, as its mass smothers the fire and does not allow a sufficiency of air to enable the wood to ignite readily. The result is that it smoulders without burning with a flame. The remedy is either to feed the sawdust on to the furnace in such a manner that it will ignite readily and burn easily, or to arrange for a draught of sufficient force to keep the burning sawdust in a perpetual state of forced ignition. The former is done by sprinkling the sawdust on to the furnace from above, in small quantities at a time, and is the usual method adopted for burning sawdust in boiler furnaces.

Another use for sawdust, which has made considerable advances in late years, is that of compressed boards of various types. A binder is usually employed to hold the sawdust together, and considerable pressure is needed to ensure rigidity,

but the resultant article is a composition board of great merit which finds a use in the many types of panelling and insulation boards now found on the market. A similar product is the sawdust briquette, also made by compressing sawdust mixed with a suitable binder, into hard bricks of a convenient size for burning. If the binder is of an inflammable nature, such briquettes ignite readily and are used as fire-lighters.

As a packing material for small articles, sawdust is well known, but for breakable goods such as glass and china wood wool is better. For litter, sawdust is superior to leaves or pine needles, as it absorbs liquid more readily and is clean and healthy. It is also extensively used in Western countries for the production of cellulose, vinegar, alcohol, sugar, and oxalic acid, and is employed in the preparation of explosives. In forest work it is useful for placing between rows of seeds in winter, and between rows of tender seedlings in forest nurseries to protect them from frost. There are numerous other uses of sawdust, but those enumerated above are sufficient to show the utility of this formerly despised by-product of sawmills and workshops.

Shavings

Wood shavings are the waste product of planing, moulding, and turning machines, and of hand planing. They are not so compact as sawdust and can therefore be used without difficulty for burning purposes. They are especially useful as kindling as they ignite readily. Shavings are also useful as litter, and on account of their springiness are often preferred to sawdust for this purpose. They are used in a great many of the same chemical undertakings as sawdust, i.e. for the production of cellulose, methyl alcohol, etc., and are often preferred as they do not 'pack' in the retorts.

Wood wool

Wood wool is the name given to fine strips of wood shaved off larger pieces of wood by special machinery. It is not correctly a waste product since it is prepared purposely, but wastewood is often used in its preparation. The fine long curly strips of wood wool may be of varying degrees of fineness, but are usually light, clean, and elastic, and when bunched together in a mass make an ideal packing material for china and glass and other fragile articles and fruit. It has also been used for stuffing mattresses, but for this purpose it is not so good as horse-hair, coconut fibre, and other similar stuffings.

Wood wool is not made extensively in India, and most of the wool used in this country is usually imported, but the Woodworking Institute at Bareilly (United Provinces) manufactures a certain amount, and has proved that it can

easily be produced in India economically. The woods used are spruce (*Picea morinda*), blue pine (*Pinus excelsa*), toon (*Cedrela toona*), deodar (*Cedrus deodara*), and semul (*Bombax malabaricum*). Spruce is by far the best as it has good springiness, and being without smell is preferred for fruit packing. Blue pine is considered the next best, and wood wool of both these timbers is now being supplied by Bareilly to the fruit orchards of the Punjab and Kumaon Hills for packing peaches, apples, and apricots.

Part II

IMPORTANT AUXILIARY UTILIZATION INDUSTRIES

VIII

SEASONING OF TIMBER

GENERAL REMARKS. SEASONING AND STORAGE OF LOGS. AIR SEASONING; general—horizontal stacking—vertical stacking. KILN SEASONING OF TIMBER.

GENERAL REMARKS

In a previous chapter, the significance of the term 'seasoning', as also the importance of proper seasoning for an efficient utilization of timber, has already been discussed. It has been explained that splitting, cracking, warping, twisting and other seasoning defects of timbers are all caused or increased by a lack of sufficient attention to the process of seasoning, and that the damage due to these defects can be greatly reduced by proper methods of stacking and handling converted timber. Since the subject is of great importance to a forest officer, this chapter is devoted to practical details of the methods of seasoning timber under Indian conditions.

At the outset it may be mentioned that all the water contained in wood is not held in one form. Part of it is present as *free water*, containing some substances in solution, distributed in the cavities of the cells and in the spaces between the cells. Another part is held as *absorbed water* by the cell walls. An analogy, though not strictly correct, will help to make this clear. If a tube made of blotting paper is closed at both ends and filled with water, the water contained in the tube can be taken as *free* water, and that absorbed by the blotting paper itself as *absorbed* water. The former can be easily removed by opening one end of the tube, but the latter takes time to evaporate. In wood similarly, the removal of the free water, although not so simple as in the above example, is easier than, and takes place before, the evaporation of the absorbed moisture. The limit of moisture content at which all the free moisture has been removed and at which the only water left in the wood is absorbed moisture, is known as the *fibre saturation point.* The importance of this point lies in the fact that wood starts shrinking rapidly only after this point is reached. In addition, above this moisture content, the strength properties of timber do not vary much, but below this point there is a rapid increase in the strength of wood as the moisture content decreases. For most of the Indian timbers, the fibre saturation point has been determined at between 20% and 30% moisture content.

The basis of expressing moisture content has already been explained. It will be remembered that the moisture contained in a piece of wood is usually expressed as a percentage of the dry weight of the wood, and not as a percentage of the initial weight. If this is kept in mind, a statement that a piece of wood contains 100 per cent moisture or more does not appear inconsistent, as it means that the piece contains an amount of moisture equal to or more than the weight of the dry wood in the piece.

It now remains to give some practical details for the determination of moisture in wood. The apparatus required for the purpose comprises a chemical balance and a drying oven, both of which are easily obtainable in any of the chemical laboratories attached to various schools and colleges all over the country. A small section about ½ inch thick along the grain, and of the full width and thickness of the board the moisture of which is to be determined, is cut from one end of the board, about 18 inches away from the end. In order to get a correct idea of the moisture content of the board, it is necessary that the wood for about 18 inches from the end should be rejected, as wood dries faster from the end than from the tangential and radial surfaces, and the ends of planks are, therefore, not always of the same moisture content as the rest of the planks. After removing any loose slivers from the section by means of a file or a sharp knife, it is weighed on the chemical balance to the nearest one-hundredth of a gramme, and dried in the oven at 100°C.–105°C. for 48 hours. At the end of this period, the section is weighed again, and the moisture content calculated according to the formula:—

$$\text{Moisture content} = \frac{(\text{initial weight} - \text{oven-dry weight}) \times 100}{\text{Oven-dry weight}}.$$

In case it is found necessary to send samples for moisture determination by post, representative boards should be selected from the whole lot, and pieces not less than six inches long and the full width and thickness of the boards should be cut from the boards after rejecting a length of about 18 inches from the end. These samples should have their ends dipped in melted paraffin wax and should be weighed immediately after cutting, and the weights recorded on them. The weighing can be done by means of any balance that may be available locally, either in ounces and drams, or in chhataks and tolas. They should then be wrapped in thick brown paper and dispatched. On receipt at the destination any change in weight during transit will be determined and accounted for in the moisture content calculation. In place of the sections of boards, shavings obtained by boring into the wood with an auger can also be used for moisture determination. These should be sealed up immediately in test tubes or small bottles before dispatch.

Seasoning and Storage of Logs

Soon after a tree is felled, evaporation of moisture from the wood starts, which, on account of the bulk of the log, is almost entirely confined to its ends,

and to the surface also if the latter is exposed by the removal of the bark. This results in stresses in the wood due to unequal shrinkage, which gives rise to numerous heart and radial shakes, end splits, and surface cracks. Once these cracks, splits and shakes start, they tend to increase during the subsequent seasoning of the converted material, and it is, therefore, necessary to take good care of logs from the time the trees are felled. If logs are left unprotected, boring beetles, termites, and wood-destroying fungi start their ravages, and it is not possible to check most of these later, except by a steaming treatment in a kiln, which unfortunately cannot be easily arranged in this country on account of the small number of kiln installations.

The practice of girdling teak logs in Burma has already been referred to. The warning may be repeated here that girdled teak is by no means *fully* seasoned, and that converted material obtained from girdled teak squares should be further seasoned before use, like any other timber.

A number of experiments on the girdling of Indian trees have been carried out at different times. From these it was found that many species are liable to insect attack during the period the trees are left girdled, while many others show a tendency to severe surface cracking, with the result that the trees when felled are badly shattered. In a few species the girdling treatment was found to be beneficial, but the practice has not so far been adopted anywhere in the country, except in the case of teak.

The storage of logs under water is sometimes known as *water seasoning*, which is obviously a misnomer, as no drying can take place so long as logs are under water. During this period, there is a possible leaching out of some of the water-soluble substances in the wood, but in the short period during which logs are usually left submerged in water this effect is practically negligible. If logs are allowed to remain in water for a number of years before conversion, the wood is said to dry more rapidly and with less degrade than unsoaked wood. The same result could probably be achieved by soaking converted material for shorter periods before seasoning it.

The storage of logs under water is undoubtedly useful in this country, as it is the best method of preventing splitting and cracking, and insect and fungus attack. Where possible, a sawmill should be provided with a log-pond for the storage of logs under water. The supply of water should preferably be from a stream or river, so that there is a continuous change of water. If the supply is from any other source, arrangements should be made for at least a fortnightly change of water. If left longer, the soluble substances leached out of the wood start fermenting, which not only gives rise to a bad smell, but also causes deterioration of the wood on account of the acids produced during fermentation.

The best method of seasoning wood is undoubtedly to convert the logs as soon as possible after felling, and stack the timber for seasoning under cover of a shelter as discussed in the next section. If, however, logs have to be stored for any length of time, and no arrangement can be made for storing them under water, the following precautions should be taken :—

(1) Raise the logs above the ground by means of skids, so as to prevent contact with soil. This gives protection against insects and fungi.

(2) Coat the ends of logs with a moisture-retardant composition, such as hardened gloss oil, a bituminous paint, or coal-tar. When none of these is available, a mixture of cow-dung and mud may be used. This end-coating reduces end-cracking and splitting.

(3) Shelter the stack of logs with thatch or some other kind of protection against the drying rays of the sun. Even a rough protection of grass and branches is better than no protection at all.

(4) If the timber is liable to insect attack, remove the bark before storage. This, on the other hand, increases the tendency to surface cracking of the timber.

These few simple precautions, if taken in time, will greatly improve the condition of the timber, and will certainly result in more efficient utilization of the wood.

Air Seasoning

General

The main principle underlying the process of seasoning is the control of the rate of drying, and regulating it within limits, so that the wood seasons with the least possible damage. There are three factors which control the rate of evaporation of moisture from wood.

These are—

(1) the temperature of the surrounding atmosphere,

(2) the relative humidity or degree of wetness of the air, and

(3) the speed of circulation of air through the stack of timber.

Air is the medium that supplies the heat necessary for evaporation, and helps to remove the evaporated moisture. Under air-seasoning conditions, the temperature and relative humidity of the atmosphere are beyond positive control, but the stack of timber to be air-seasoned can be given protection against these by the provision of suitable sheds.

According to the ease or difficulty with which they air-season, Indian timbers may be classified into three broad groups, as follows:—

(i) **Most refractory.**—Those timbers which are liable to excessive splitting and cracking during the seasoning process. These should be very well protected

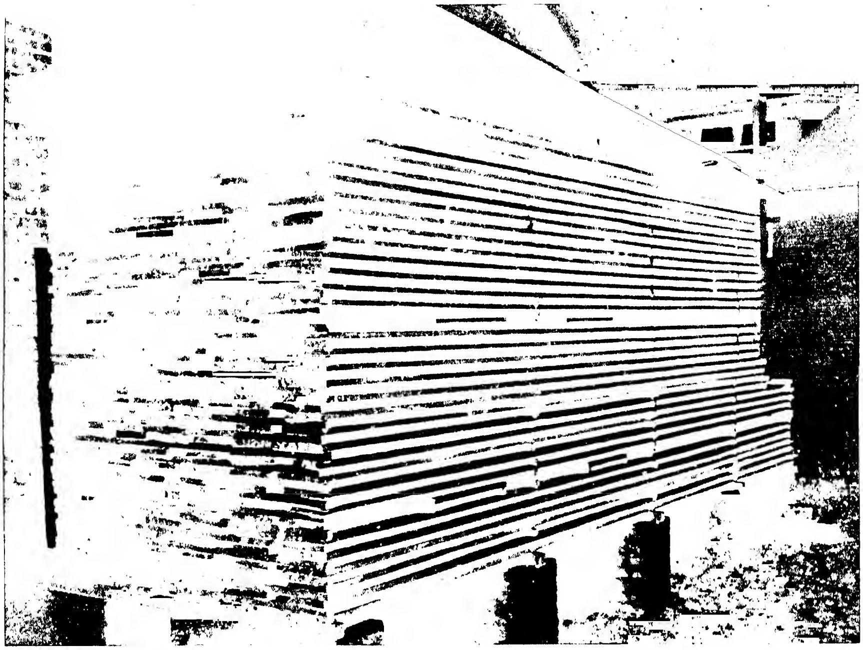


PLATE VIII. Sawn timber well piled for air seasoning

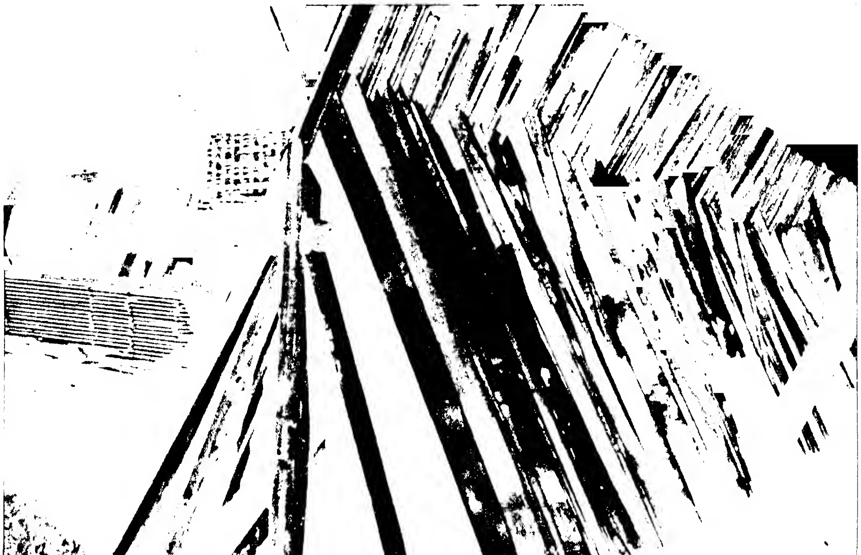


PLATE IX. Vertical piling of sawn timber for quick air seasoning

Facing p. 193.

against hot, dry winds. Examples of this class are *Anogeissus latifolia, Lagerstroemia parviflora, Shorea robusta, Terminalia tomentosa,* and *Xylia xylocarpa.*

(ii) **Moderately refractory.**—Those timbers which are moderately liable to splitting and cracking during seasoning, but, if given partial protection against rapid drying, should season with very little depreciation. Examples of this class are *Adina cordifolia, Albizzia lebbek, Cedrela toona, Dalbergia latifolia,* and *Pterocarpus marsupium.*

(iii) **Non-refractory.**—Those timbers which are capable of withstanding rapid seasoning, but which are generally liable to staining, mould and decay. These should be stacked openly for as speedy seasoning as possible. Examples of this class are *Acer campbellii, Bombax malabaricum, Sterculia campanulata,* and *Trewia nudiflora.*

In any particular instance, the amount and type of protection required depends upon (*a*) the nature of the timbers to be seasoned, (*b*) the dimensions of the stock, and (*c*) the climatic conditions of the place. In designing a seasoning shed for any particular set of conditions, a number of other factors have also to be taken into consideration. Advice in this regard should, therefore, always be sought from the Forest Research Institute, Dehra Dun, which has information on most Indian species and for many localities in India, which is at the disposal of all forest officers and others interested in air-seasoning problems.

Speaking broadly, under dry climatic conditions like those of the Punjab, the most refractory timbers should be stacked in a shed closed on all sides and having openings only for the necessary ventilation, preferably provided with shutters; the moderately refractory timbers in a shed open on the north side; and the non-refractory species in the open, having protection only against direct sun and rain. In a damp coastal climate, on the other hand, a shed open on the north side is enough for the most refractory timbers, a shed open on all sides for moderately refractory timbers, while non-refractory timbers should be stacked immediately, after green conversion, in a vertical fashion in the sun for extra rapid drying.

Success in seasoning, however, depends also, to a very great degree, on the care taken in stacking the timber. The following hints may be of help in this connexion.

Horizontal stacking

(1) **Foundations.**—In order to allow a free circulation of air under the pile, it should be raised about 12 to 18 inches above the ground level by means of brick, concrete or wooden piers. If wood is used for the purpose, it should

be given a coat of hot creosote or coal-tar. Tops of piers should be level, so as to provide an even bearing surface for the pile to rest upon.

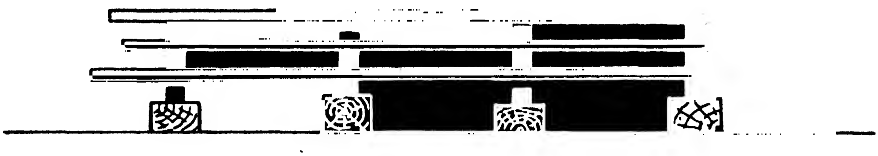
(2) **Sorting out of lengths.**—As far as possible, pieces of equal length should be piled together in the same stack. Where material of unequal lengths must be piled together, the longer pieces should be sorted out and placed at the bottom of the stack. Long pieces should never be allowed to overhang shorter ones, as this results in distortion of the wood.

(3) **Width of pile.**—The most suitable width for a stack of timber is about 5 ft. Wider stacks result in slow and irregular drying in the centre.

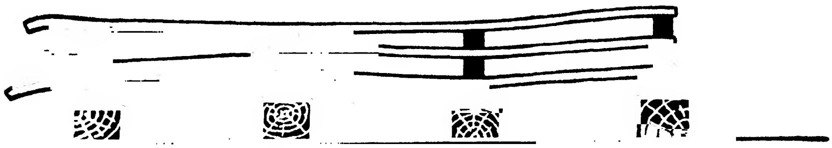
(4) **Height of pile.**—About 12 ft. from the ground is a good height for a timber stack. In higher stacks, the bottom portion lags behind the top portion in drying, and consequently the timber has to be left stacked for a longer period than would be necessary for a lower stack.

(5) **Spacing between piles.**—A distance of about 2 ft. should be left between adjacent stacks for the proper circulation of air.

(6) **Crossers.**—Thin battens of wood used for separating one layer from another are called crossers. They should be of sound wood, straight, and uniform in thickness. For most purposes, one-inch thick crossers are the most suitable. They should be about 2 inches wide and as long as the width of the pile. The distance between crossers in a layer should be not more than 2 ft. in the case of one-inch thick planks. They should always be in a vertical alignment, and not 'staggered' from one side to the other.



Before drying.



After drying

DIAGRAM 6. The effect of uneven foundations on timber piles. Even if the crossers are of uniform thickness, the whole stack of timber will be spoiled if the foundations are not level

(7) **Spacing between planks.**—In any layer, a side spacing of about one to two inches should be allowed between adjacent planks.

(8) **Roof.**—If the stack is made in the open, it should be inclined towards one end to allow rain-water to drain off as easily as possible. The stack should preferably be provided with a roof made of rejected planks to shelter it from sun and rain. Decayed or insect-attacked planks should not be used for this purpose. Heavy weights such as metal rails or large baulks of wood are also useful if placed on the top of a stack, as they prevent any distortion or warping of the timber in the stack.

These points are illustrated in the photograph (Plate VIII), showing a stack of timber well piled for air-seasoning.

Vertical stacking

The usefulness of this method is limited to short preliminary drying treatments prior to horizontal stacking under cover for complete seasoning, for woods inclined towards blue-stain, decay and fungus attack, such as *Bombax malabaricum*. A photograph showing a vertical stack of timber can be seen in Plate IX. It should be noticed that the bottom ends of the planks rest on wooden boards, to prevent contact of the timber with the soil. The rapid circulation of air brings about speedy drying of the surface layers of the planks, thus preventing development of fungus. When stacking planks vertically for quick drying the lines should be in the form of an inverted V thus Λ, and not in the form of a cross thus X, as this usually results in the ends at the top cracking and warping.

Kiln Seasoning of Timber

The methods of kiln drying are fundamentally the same as those of air seasoning, the only difference being that in a seasoning kiln the conditions of drying, i.e. the temperature, humidity, and circulation of the surrounding air, can be kept under perfect control, and can be regulated to dry the timber in the shortest time possible and with the least degrade. The kiln drying of timber has the advantage over air seasoning that the period of drying is greatly shortened, and well-seasoned material is obtained in very good condition. On the other hand, the cost of kiln drying is very high for small installations, so that the application of this method of seasoning is only economical for wood-using industries with a large output. In the case of non-refractory timbers liable to stain and fungus attack, kiln drying is particularly suitable on account of the sterilizing action of the steam heat on fungus spores and insect larvæ. Kiln-dried timber also remains immune from stain and decay, unless it is allowed to get wet again and is re-infected from a new source.

A seasoning kiln is essentially a chamber in which the timber is stacked in much the same way as for air seasoning, and in which hot air at a specified

temperature and humidity is allowed to circulate. The air is usually heated most economically by steam, and the circulation is generally brought about by fans situated either inside or outside the kiln. The humidity is usually regulated by means of exhaust chimneys, steam jets or water sprays. There are various types of kilns, each suitable for particular purposes, but it is beyond the scope of this Manual to go into the details of their design and construction, and anyone wishing to investigate the possibilities of kiln drying for any particular project would be well advised to refer the matter to the Forest Research Institute before launching out on any such scheme.

IX

PRESERVATION OF TIMBER

GENERAL REMARKS. RELATION BETWEEN THE STRUCTURE AND THE TREATABILITY OF WOOD. SELECTION OF PRESERVATIVES; for outside locations—for inside locations—for inside work under wet conditions. METHODS OF PRESERVING TIMBER ON A SMALL SCALE. PRINCIPLES UNDERLYING PRESSURE WOOD PRESERVATION. COMMERCIAL PRACTICE. FIREPROOFING.

GENERAL REMARKS

The object of the science and practice of wood preservation is to prolong the life of perishable timbers. With the passage of time, all building materials deteriorate during service; steel rusts and corrodes, brickwork or concrete disintegrates, while wood is destroyed by the action of fungi and insects. The forces of nature are too strong for most building materials to resist permanently without eventually breaking down, and timber is no exception. The factors which tend to destroy timber in service have been discussed in Chapter I (pp. 26–32). After what has been recently achieved in the science and practice of wood preservation, considerably more importance is now attached to the 'artificial durability' of wood, as distinct from its 'natural durability'. 'Artificial durability' is obtained by impregnating the wood with preservative chemicals. If wood is not preserved artificially the natural durability and mechanical strength of the wood are the two most important characteristics which govern the selection of a timber for structural purposes. In the present state of our knowledge, the intrinsic strength of seasoned timber cannot be increased, but the durability of timber can be enhanced by more than 10 times, in some cases, by impregnation with a good preservative, and this preservation process can be regulated to suit every type of requirement in order to obtain the most economical and efficient results. If structures like bridges, sleepers, and telegraph poles are made of the heartwood only of the most naturally durable and expensive timbers like teak, sal, and deodar, they cannot always compare in cost with similar structures made of other materials, but when the artificial durability of cheap perishable timbers like chir (*Pinus longifolia*) or the sapwood of the above timbers is investigated, the position is often reversed, because of the greatly increased durability that can be obtained with very little extra cost. It is because full advantage of the artificial durability of Indian timbers has not been taken in

the past that steel and reinforced concrete are at present more popular than timber for use in structures in this country. The potentialities of treated timber are however beginning to be appreciated. Iron and steel have to be painted or galvanized to ward off rust or corrosion. This coating is only superficial and is not a permanent method of protecting the materials underneath, so that when the veneer of paint or zinc comes off at any place, a focus of deterioration is created. With timber, artificial protection is not merely superficial, but can, in the case of many timbers, be extended to the entire volume of the piece of timber in question, depending on the method of application and the species of wood used. In the case of perishable woods, protection throughout should be aimed at. In woods with durable heartwood, treatment of the perishable sapwood is sufficient. Pressure-treated timber requires no maintenance in the way of retreatment, as is the case with iron or steel which need repainting. This fact makes the preservative treatment of wood a more efficient and economical process than the comparatively temporary and superficial protection of iron or steel with a paint or zinc coating.

Relation between the Structure and the Treatability of Wood

The heartwood of hardwoods with clear untylosed vessels and with considerable parenchymatous tissue around the vessels is more amenable to treatment with preservatives than other types of hardwoods such as those with tylosed vessels and little parenchymatous (thin-walled) tissue. In the case of coniferous woods, it is usually accepted that the penetration of preservative fluids takes place through the bordered pits in the tracheid walls. The sapwood of practically all Indian woods treats easily, deodar being an exception to this rule.

A lot of obscurity exists as regards the relation between the structure of wood and its amenability to treatment. Fairly soft woods like spruce (*Picea morinda*) or fir (*Abies webbiana*) may be very refractory to treatment, while quite hard timbers like kusum (*Schleichera trijuga*), and laurel (*Terminalia tomentosa*), can be impregnated with ease. Again, the heartwood of chir pine (*Pinus longifolia*) can be treated fairly satisfactorily, while it is difficult to impregnate the heartwood of blue pine (*Pinus excelsa*). The reason for this is at present obscure. In the case of conifers, the denser summerwood can be impregnated more satisfactorily than the less dense and more porous springwood. A lot of hypotheses have been advanced to explain this apparent anomaly, but none of them is quite satisfactory. Though the precise mechanism of the penetration or movement of fluids in wood is not always quite clear, a microscopic examination of the structure of wood usually gives a clue as to the amenability or otherwise of a timber to impregnation with preservative fluids.

Selection of Preservatives

A good wood preservative should satisfy certain conditions if it is to prove efficient in service. Amongst these conditions the following are of primary importance:—

(1) It should be easily available in good quantities at a relatively low price.
(2) It should be toxic in small doses to wood-destroying fungi and insects like termites and wood-borers.
(3) It should not have a low volatility, or be easily leached out of wood when exposed to moist conditions.
(4) It should not reduce the strength of wood treated with it.
(5) It should not be dangerous to use, but must be poisonous to lower organisms. It should also not be disagreeable to handle.
(6) It should preferably be colourless and without objectionable smell.
(7) It should not prevent wood impregnated with it from being painted or stained.
(8) It should not have any corrosive or chemical action on iron or steel.
(9) It should not increase the inflammability of timber. If it is a fire-retardant so much the better.
(10) It should not exude from the wood during summer or when exposed to high temperatures.
(11) It should have a low viscosity and should penetrate wood satisfactorily.
(12) It should not, if possible, be decomposed by heat below 100°C.

As the conditions required for different uses are often conflicting, a wood preservative that is ideal for all purposes has not yet been discovered. It is necessary, therefore, to make a selection based on the use to which the treated timber is to be put.

The following simple but reliable recommendations may be noted regarding the choice of cheap and efficacious wood preservatives for everyday use. Most proprietary preservatives are like patent medicines, they cost very much more than they are actually worth. This information is useful knowledge in view of the fact that there are several wood preservatives on the market which cost several times as much as the preservatives mentioned below, though they are not more efficacious.

For outside locations

Where very moist conditions prevail, such as in tropical and temperate districts infested with termites, coal-tar creosote and certain arsenic preparations are recommended. Even in dry localities, where termites do not abound, these preservatives appear to be the most economical and efficient, but other

preservatives can also be used in such localities without disadvantage. Of these, zinc chloride and sodium fluoride (where there are no termites) are usually the most effective.

For inside locations

Under *dry conditions*, coal-tar creosote, arsenic salts, sodium fluoride and zinc chloride are indicated. The first has some objections against its use in some cases. Its higher cost in India, objectionable smell and oily nature, and the disadvantage of being unable to paint over creosoted wood are some of the factors which militate against the use of coal-tar creosote for the interior of houses and other buildings.

For inside work under wet conditions

Coal-tar creosote and magnesium or sodium silico-fluoride are recommended for use in such localities as ship's refrigerator rooms, moist basement rooms, mines, etc.

Methods of Preserving Timber on a Small Scale

Wood preservatives can be applied to wood in three ways, namely:—

(1) by brushing or spraying the preservative on to the wood,
(2) by soaking or dipping the wood in the preservative,
(3) by injecting the preservative into the wood under pressure.

Except for a few purposes, the first two processes cannot be considered as very efficient. They are however generally sufficient for preserving well-seasoned timber in dry interior locations.

The most efficient method of wood preservation is the third, which involves the use of high hydraulic pressure in a closed cylinder and is known as 'pressure treatment'; but this method is not always possible for the small agriculturist or householder, who usually wants to treat only a small quantity of building timber or fence posts at a time. Building timber may be sometimes painted over with the preservative, but fence posts and other materials to be used partly or wholly in the ground in outside locations should, if a pressure plant is not available, be treated by giving them a soaking or dipping treatment, which is usually called an 'open tank' treatment. This open tank treatment consists in placing the wood in a barrel or tank containing the preservative fluid, which can be heated by a fire below if a hot treatment is to be given. Depending on the dimensions, the timber should be left submerged in the hot fluid for 2 to 4 hours. The fire should then be withdrawn and the preservative allowed to cool *with the timber still remaining in it.* This is important, as timber immersed in a hot fluid becomes

warm, and some of the air in the wood expands and is forced out, creating a partial vacuum in the cells and cell spaces of the wood. As the liquid cools the wood cools down too and some of the preservative is sucked in to fill the vacuum. While this process is sufficient for impregnating fairly satisfactorily the sapwood of the majority of Indian timbers, there is hardly any wood which receives a really satisfactory impregnation in the heartwood by using this open tank method of treatment. It is also a process which is not so efficient with preservatives used cold as with those used hot. It is however a process not infrequently employed with creosote, which should preferably always be used hot. Where timber is to be treated in the round, and when the heartwood of such timber is naturally durable, an open tank treatment may be considered as satisfactory for certain purposes. It must be remembered that the sapwood of practically any timber can be impregnated easily with antiseptics. It is only when the question of impregnating the heartwood is concerned that different degrees of amenability to treatment, depending mostly on the structure of the wood, are observed.

Principles underlying Pressure Wood Preservation

Treatment under pressure is the best and only really efficient process of wood preservation for all conditions of service. In general, Indian timbers can be divided into four classes for pressure wood preservation purposes. These classes are as follows :—

(1) Those timbers of which the heartwood is very porous and which can therefore be treated very easily. The problem in this case is to get an economically low absorption, and hence to control the absorption of the antiseptic within a certain superior limit consistent with thorough penetration.

(2) Those timbers of which the heartwood can be impregnated with difficulty—the other extreme to the first case. The problem here is to obtain an efficient penetration in the heartwood without attempting to control the absorption.

(3) Those timbers of which the heartwood can be impregnated with moderate ease, the problem in this case being to secure efficient penetration consistent with economical absorption.

(4) Those timbers which are so refractory that they cannot be treated economically.

In the case of timbers of the first class, pressure treatment is effected by placing them in a steel cylinder, which is then closed. Air is then pumped into the cylinder, and a pressure is maintained for a certain time. After maintaining

this air pressure, usually for a few minutes, the cylinder is filled with the antiseptic fluid. When the whole cylinder is filled, more antiseptic is pumped into it under pressure until the pressure in the cylinder rises to about 10 to 12 atmospheres, when the pressure is suddenly released. When this releasing of the pressure takes place, the compressed air in the cells and spaces of the wood, especially in the surface and end strata, tends to expand to normal atmospheric pressure, and in doing so expels a large proportion of the antiseptic absorbed in the wood. A final vacuum is then drawn, to recover some more of the surplus antiseptic which was forced into the wood under pressure.

With the second variety of timbers, an initial vacuum is drawn, and maintained for a certain period not usually exceeding an hour. The air in the surface layers of the wood is thus partly drawn out, so that a partial vacuum prevails in the cells of the wood, especially on the surface and at the ends. While maintaining the vacuum, the antiseptic is pumped under pressure into the cylinder as in the first process referred to above. A short final vacuum (not with the object of recovering any antiseptic, but to obviate dripping and loss of the antiseptic from the treated wood) completes the process. The total recovery in this process does not usually exceed about 10 per cent of the gross absorption.

With the third class of timbers, namely those that treat with moderate ease, neither an initial vacuum nor compressed air is required. Air occluded in the wood cells is taken advantage of. The antiseptic is pumped straight into the treatment cylinder. Pressure is applied, and when this is released there is a 'kickback' of about 30 to 50 per cent of the initial gross absorption, due to the compressed air in the cells of the wood expanding to the normal atmospheric pressure. A final vacuum, of usually about 45 minutes' to an hour's duration, completes the process.

The first and third processes definitely aim at recovering 30 to 85 per cent of the total initial gross absorption. They are known, broadly, as 'empty-cell' processes; and specifically (after the names of the inventors) as the Rueping and Lowry processes respectively. The second type of process, namely that used for impregnating refractory timbers, is called the 'full-cell' process. The empty-cell processes were discovered hardly thirty years ago, whereas the full-cell process has been known for over 80 years.

Commercial Practice

Though structural timber can be impregnated in open tanks, this process is, especially for the use of treated timber outdoors, neither very efficient nor very economical. It is not recommended when work is to be carried out on a moderately large scale. Unless the amount of timber to be treated is very small

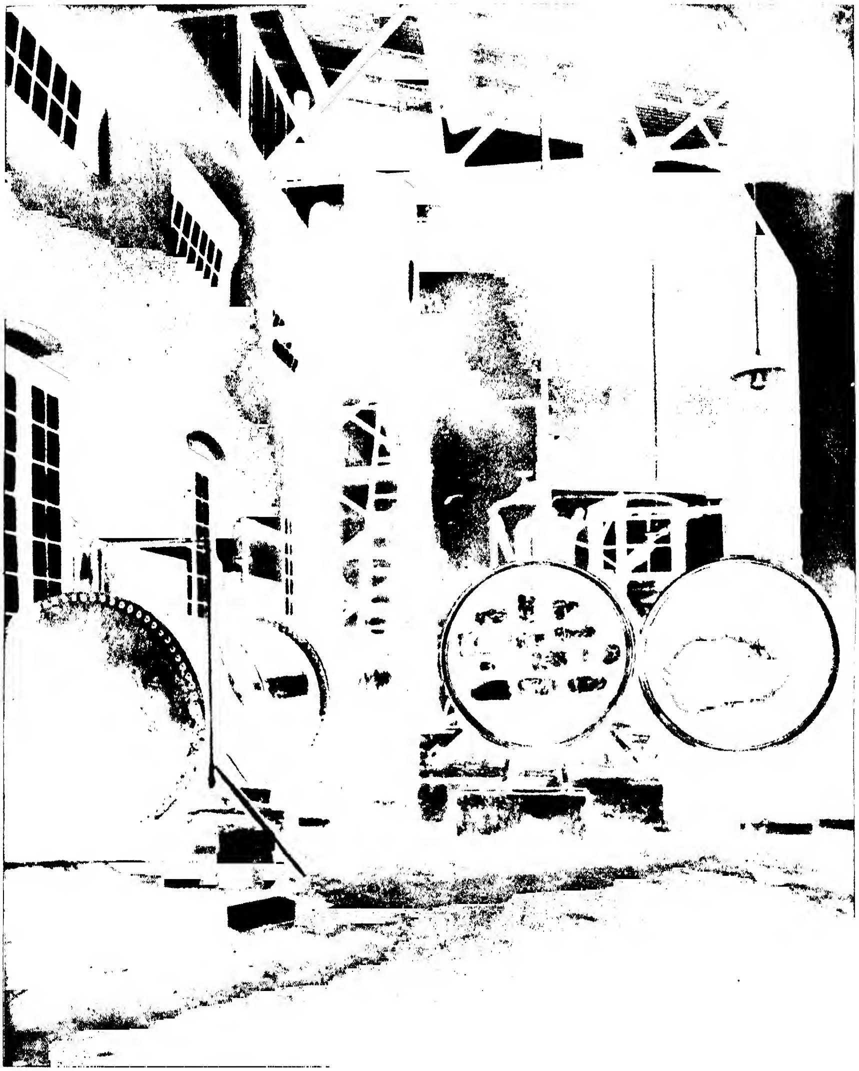


PLATE X. A wood preservation plant
The pressure cylinder is shown open, and storage tanks are on the left

Facing p. 202.

and is to be used in dry inside locations, it is always advisable to impregnate under pressure according to one of the three processes outlined above.

A typical commercial wood preservation plant consists essentially of:—

(1) An air-seasoning yard where the timber is properly piled to air-dry. Wood is not, in general, ready for treatment till the moisture content is below 20 to 25 per cent.

(2) A mild steel cylinder (fitted with a suitable door) which can take the timber for impregnation.

(3) The machines required for drawing a vacuum, and creating pressure.

(4) Trolleys, cranes, and a railway line for transporting the material to be treated.

(5) A boiler for the supply of steam to work the machines and to heat the antiseptic if a hot treatment is to be used.

(6) Storage and working tanks to hold the antiseptic.

Fireproofing

Wood can be made fire-resistant so that when exposed to fire, it will only char and not burn. To 'fireproof' wood, impregnation with a chemical solution is required, as in the case of antiseptic preservation. The most efficacious commercial fire-retardant chemicals are ammonium mono- or di-phosphate, sodium arsenate, and borax (sodium tetraborate). They may be impregnated into the wood, normally, in a 2 per cent solution. The remarks made above with reference to the mechanical aspect of impregnation with wood preservatives apply with equal force to fireproofing timber. The timber must be properly air-seasoned after the treatment. It should however be noted that wood cannot be made completely fireproof, and for this reason the expressions 'fire-retardant' or 'fire-resistant' are preferable to the loosely applied term 'fireproof'.

X

SAWMILLS AND WOOD WORKSHOPS

PERMANENT SAWMILLS; power plant—main shafting—countershafting—belting—machines. PORTABLE SAWMILLS. SOME SAWING-MACHINE TROUBLES AND HOW TO AVOID THEM; rules for calculating the speeds of pulleys and saws. CONVERSION.

There are, in general, two types of sawmills: (1) sawmills established on a more or less permanent site, and (2) sawmills of a portable or semi-portable nature, which can be moved from place to place.

PERMANENT SAWMILLS

Mills of a permanent character are usually situated either close to or in cities, and many of them undertake what is known in the trade as 'public sawing and machining', i.e. they convert material for cabinet manufacturers, joinery shops, small jobbers, and allied trades who have not sufficient milling work to justify the establishment of mills for their own requirements.

For success in a sawmill undertaking, much depends upon the layout and general arrangement of the mill. Improperly selected machinery, and machines laid out in poor sequence, result in unnecessary extra handling of material, and are fruitful causes of inefficiency.

Millmen differ in their opinions as to the best form of mill arrangement, and no hard and fast rules in this connexion can be laid down.

Permanent mills, public or otherwise, do not always confine themselves to the breaking down of logs into beams, planks and scantlings, but frequently machine material to a point ready for assembling into such products as doors, frames, sashes, flooring, match-boarding, and mass-production commodities.

It will, therefore, be seen that the layout of a mill is governed, to a great extent, by the work required from it, and the millman must of necessity consider all points before selecting and fixing his machines in position. In short, the object must always be to lay out the mill with an eye to general efficiency for the purpose for which it is intended, combined with speed and good quality of output at the lowest compatible overhead and other charges.

The mill building and store sheds for converted material must receive their share of consideration. A badly designed mill building in which machines are cramped and the light poor, and where it is inconvenient or impossible to run

material through the mill in sequence from the log to the finished product, will result in considerably greater loss in efficiency than that experienced in a judiciously designed building.

Up-to-date mill buildings are usually rectangular, the length being two to three times the width, with good side and top lights, and a large entrance and exit at either end to permit logs being brought into the mill at one end, and, after going through the machining process, being passed out at the other end as finished products.

Where steam engines are the prime movers it is usual to install the boilers in an annexe to the mill.

The handling of both large and small timber will weigh heavily on the debit side of production costs if a study is not made of this all-important point, and it may be mentioned that most large well-managed mills are provided with tramways, quick lifts, overhead electric hoists, gantries, jib cranes and other contrivances for reducing handling costs and speeding up production.

Thought must also be given to the site and position of the mill with relation to the transport of logs and finished products. If a waterway is convenient, the entrance of the mill should, if possible, be within easy access of the water to avoid excessive hauling. To simplify handling, the breakdown machines should be positioned in such a manner that logs can be handled by these machines as they arrive from the water, and the lighter converted material passed through the mill to other machines later.

The selection of machines, too, is a matter for serious consideration, and will depend entirely upon the class of milling to be done. For example, mills attached to railway carriage and wagon shops require extra and different types of machines to those in a mill dealing only with the breaking down of logs into planks, scantlings and similar stock.

Again, there are different types of machines for doing the same class of work, each possibly having certain advantages over the other, and the millman must, therefore, consider carefully which type is best suited for his particular mill. Initial cost must also be taken into consideration.

In explanation of this, let it be assumed that machines for breaking down logs are under consideration. The first question to decide is that of capital outlay. After this it must be decided whether very accurate cutting without regard for speed of output is required, or whether speed of output outweighs other considerations.

One type of machine may give speed of output with heavy conversion losses, while another machine may give a much smaller output with low conversion losses. Some machines do not consume the same quantity of power as others. This is an important point, as is also the question of maintenance, whereby some

kinds of saws require the continual attention of an expert 'saw doctor' to keep them in good condition, whilst others are more or less foolproof and require very little doctoring. The question of maintenance, therefore, requires careful consideration, and it may not be out of place to mention that it is a point which often does not receive the attention it merits, and sawmills in India have been known to fail through lack of proper attention being paid to saw maintenance.

There may be other reasons for and against different types of breaking-down machines, but those mentioned are sufficient to give some idea of the importance of discreet selection of machines for the project in view.

(1) *Power plant*

This may be in the form of high-pressure steam engines linked up to suitable boilers, or the machines may be electrically driven, the power being supplied by some local agency or generated on the premises.

The horse-power of the engine and boilers will be governed by the load it is intended to place upon them, but prudent millmen usually install engines and boilers of a horse-power in excess of actual requirements, to permit an overload and possibly the introduction of extra machines.

As a power agent, electricity can be used either for driving the main line shaft, which transmits power to the several machines through belts, or for driving self-contained machines.

The self-contained machine is a modern innovation in which the power unit is integral with the machine. This fact gives self-contained or 'motorized' machines several advantages over those driven by means of belts. In the first place, the drive is direct, and as there is no belting, belt slip is eliminated, and power loss by belt and shaft loads is saved. Finally, machines having their own motor and starter are under the complete control of the operator, who can work or stop each machine as and when required, without having to keep a main shaft running for one machine while others may be idle. This results in economy in running costs and efficiency, and 'motorized' machines are rapidly gaining favour in the milling industry.

(2) *Main shafting*

Except where self-contained machines are employed, a main shaft for transmitting power from the prime mover to the machines must be provided. These shafts, to which countershafts are usually connected, are fitted with pulleys, of a size suitable for attaining the desired machine speeds, and are preferably situated in pits under ground.

The diameter of the main shaft depends upon the load to be placed upon it, but no larger shafting than is actually required should be used. The general

rule is to install 3" to 4" main shafts for driving many and heavy machines. Countershafts and main shafts for driving light machines may be as low as $2\frac{1}{2}$" in diameter, or even less in some cases, depending on the power to be transmitted.

Wherever possible, it is advisable to run all shafting in roller or ball bearings. This will reduce wear and tear, friction and power demands. A good form of lubricating system must be provided.

The distance between bearing points is controlled by the torsional and bending strains placed upon the shaft by belt tension, speed, and the number of pulleys to be employed. Usually between from 4 to 9 ft. distance between pillars will be found suitable for most layouts. Speeds of between 250 and 300 revolutions per minute are generally considered to be about right for main shafts.

(3) *Countershafting*

Countershafting consists of any intermediate shaft, or set of shafts, connected up to the main shaft by means of belts. A countershaft has various uses and can be assembled to perform one or more functions at the same time. Several pulleys can be attached to a countershaft, each of which can be arranged to serve a different purpose. By connecting up, either directly or through other countershafts, to a main shaft, it is possible to lay machines in any desired position on a mill floor, and by means of straight or cross-driven belts a forward or reverse motion can be obtained. Economy in floor space is the result of a judicious use of countershafts, which also serve as a method by which to adjust the speed of machines or parts of machines without altering the speed of the main shaft, which should remain constant. Countershafts are frequently fitted with loose pulleys which run free on the shaft, so that when it is desired to bring a machine to a standstill, the belt, which is transmitting the power, is slipped from the fixed pulley to the loose pulley, by means of a 'striking' or belt-shifting gear.

(4) *Belting*

Owing to the variation of loads, and to the high speeds at which belting is run, it is essential that proper selection and care be given to all belting. Various kinds of belts are to be found on the market, and they are usually made up of leather, woven hair, woven cotton or rubber. These belts vary in price and quality, and all will possibly give the service claimed for them if properly looked after. It is however advisable, even at a little extra initial cost, to install the best belts procurable at the outset as they will pay for themselves in the long run.

There are three common methods of joining the ends of belts together, namely: butt jointing, spliced jointing, and staggered jointing. Whichever type of joint is adopted, it is essential to see that one edge of the belt is not

longer than the other, otherwise the short side will run towards the crown of the pulley and possibly give trouble.

Many devices have been used as a means for fastening the ends of belts together, the commonest being wire lacing, hide lacing, 'Alligator' fasteners, and Jackson's fasteners and solution. When fixing new belts, it is a common practice to ascertain the length required by doubling the length between pulley centres and adding half the circumference of each pulley. This gives allowance for belt stretch.

All belting should be examined frequently, particularly during monsoon weather, when belts have a tendency to contract and become taut when out of use, even overnight. Belts should be kept pliable and should have a good grip on the crown of the pulleys.

Belts should not be too taut or be run over pulleys at too close centres, and it is advisable to have the pulleys a little wider than the belt. Finally belts must always be of a width and thickness suitable to transmit the horse-power required of them.

(5) *Machines*

For the initial conversion of logs into planks, etc., the following machines are amongst those most commonly used: vertical and horizontal band sawing machines, rack circular saw benches, log frame sawing machines, band and circular re-sawing machines, self-acting saw benches, cross-cut sawing machines, and edgers.

Other machines which are likely to find a place in a general purpose machine shop are small ripping and cross-cut circular saw benches, surfacing machines or combined over-and-under planers, band scroll saws, thicknessing machines, power-feed moulding and matching machines, spindle irregular moulding machines, tenoning machines, chain mortising machines and boring machines. There follows a brief description of some woodworking machines :—

The **rack circular saw**, as its name implies, is fitted with a circular saw, which is a disc of steel with teeth at regular intervals round the rim or edge. The log which is made fast to a travelling carriage moves forward towards the saw, which, whilst revolving at a rim speed of between 9,000 and 10,000 feet per minute, engages with the wood and chisels its way through.

The **log band saw** is fitted with two saw pulleys, set either vertically or horizontally, over which is strained a ribbon or band of steel having suitably shaped teeth cut into either one or both of its edges. As the saw pulleys revolve, the saw is carried round in a continuous motion, and engages with the timber which is fed towards it by means of a travelling carriage.

The **log frame sawing machine** consists of a saw frame in which a number of straight frame saws are fastened vertically. The saws work with a reciprocating motion, and being spaced apart to any given distance, produce several planks, scantlings or beams at one operation.

Opinions differ as to which is the best type of log saw. Much can be said in favour of both the band and circular types of 'breaking-down' saws. A special feature of the band saw is that it is generally constructed to convert logs of a bigger girth than those which can be conveniently handled with the circular type. As the gauge of a large band saw is usually considerably less than that of a large circular saw, the saving of timber resulting from the smaller kerf, i.e. the portion of timber removed by the saw in the form of sawdust, is another advantage which the band saw has over the circular saw. On the other hand, band saws require the attention of an experienced and competent saw expert, usually known as a 'saw doctor', who must thoroughly understand tensioning, hammering, and rolling, etc., if saws are to be kept in good running order.

Band re-sawing machines are a modification of the log band sawing machine. They are usually fitted with a fence, and are used for re-sawing timber into sizes not convenient to obtain from the log breaking-down machines.

Circular re-sawing machines do the same work as band re-sawing machines, but are fitted with circular saws instead of bands. Some sort of self-acting feed is usually fitted to these machines to feed the timber to the saw.

Cross-cut sawing machines are used for cutting logs into convenient lengths for handling, and also for cutting converted material into correct lengths. There are several types of cross-cut sawing machines, of which some are specially designed for cutting logs and others for cross-cutting planks and similar stock. Reciprocating, circular, and chain cross-cut saws are used for log work, and pendulum and bench circular cross-cut saws for small work.

A surfacing machine is invaluable in a general mill. It is used for edging, facing, taking out 'wind', chamfering, rebating, and truing up. These machines run at high speeds, and as a result the frames have to be of solid construction and mounted on a good heavy base to absorb vibration. To adjust for depth of cut the tables both in front and behind the cutter block are capable of independent vertical adjustment.

Thicknessing machines.—There are several modifications of thicknessing machines on the market, and the choosing of such machines, or for that matter any machinery, is a matter of personal requirements. It is, however, a good policy to avoid machines having too many complications and intricate parts. The function of the thicknessing machine is to bring timber down to a given thickness after it has been faced and edged on a surfacing machine. The machine

is fitted with top and bottom cutter blocks, each carrying two or more knives, and the timber is fed to the knives by means of fluted rollers. Pressure bars are provided to hold the timber down on to the table during the cutting operation.

Over-and-under planer.—This machine is a combination of a surfacing machine and thicknessing machine. It does all the work usually performed on a surfacing machine, and has, in addition, an independent rising and falling table, placed below the cutter block for planing to thickness.

Band scroll sawing machine.—A serviceable band scroll saw for light work, such as cutting irregular curved lines, is one with saw pulleys of 24 to 30 inches diameter. These pulleys are imposed above each other, and a small band or ribbon of steel having teeth along one edge is strained over them, and rotates round them when the machine is running.

Power-feed matching and moulding machines are usually of a complicated character carrying several horizontal and vertical cutter heads which can be fitted with shaped cutters for introducing mouldings, tongues and grooves on prepared stock. The timber is fed to the cutters by means of rollers, and the machine is so constructed that all four sides of a piece of timber can be dealt with at one operation.

Spindle irregular moulding machines are for cutting mouldings in straight and irregular shaped timber. By means of special apparatus, dovetailing and small tenoning work can be neatly executed on such machines. Balanced cutters, of the shape required for the work in hand, are mounted in a vertical cutter head which revolves at high speed, and the stock to be moulded is fed to the cutters by hand.

Tenoning machines.—There are various forms of tenoning machines, and selection must depend entirely on the size and style of work to be done. In general, the machines are usually fitted with cutter spindles capable of cutting tenons with shoulders of different lengths. The cutters are arranged to give a shear cut and can usually produce single tenons, double tenons, bottom scribing, top scribing or both.

Mortising machines can be obtained to operate either vertically or horizontally, and like most other woodwork machines there are various types, such as hollow mortisers, chain-cutter mortisers, combined chain and hollow chisel mortisers, and combined bit and hollow mortisers.

Boring machines.—For light boring work, any of the following types of machines are equally good: pillar, wall, vertical, or horizontal boring machines. Preference might be given to the machine which provides for the bit being brought to its work by means of a lever or handwheel, rather than the type of machine which requires that the timber be fed by hand to and from the bit.

Saw fitting shop.—As the output of a sawmill and machine shop depends in a very great measure on the condition of the saws, planing knives, cutters and other machine tools, most up-to-date mills maintain a well-equipped fitting shop for the purpose of keeping all tools in perfect order. The men employed in these shops must thoroughly understand their work if success is to be attained.

The room, which should be well lit, should, for preference, be set apart from the mill and machine shops. The requirements of a tool room include grinding machines for shaping moulding cutters, saw-sharpening machines suitable for sharpening and gulleting either frame or circular saws, band saw filing machines, band saw setting machines, brazing clamps and brazing material, heating appliances for brazing work, band saw stretching rolls, automatic knife-grinding machines, grindstones, grinding apparatus for chain mortise cutters, cutter balances, a forge, various grades of emery wheels and files, steel straight-edges of various lengths, swage sharpeners, side dressers, saw sets of various sizes, set gauges, an anvil and hammers for tensioning, high-speed tool steel for cutter making, and material for saw packing.

As is the case with woodworking machines, there are many types and modifications of the machines used in the tool room, and the following brief descriptions will give an idea of the variety of machines usually employed in a tool shop.

Grinding machines for moulding cutters.—These machines are designed for shaping and grinding cutters of irregular patterns. They are usually fitted with several stones of various grades and thicknesses, to enable the operator to obtain any desired shape. Tool rests and a water cistern fitted with water taps are usually provided with the machine.

Saw-sharpening machines.—There are several types of saw-sharpening machines on the market, some of which are automatic in action. These machines are fitted with emery stones, and refinements for tilting the stone to obtain any desired grinding angle. The saw teeth are automatically fed to the emery stone, and when once 'set up' the machine will complete the work it is set to do with very little further attention.

Hand-operated models are usually constructed with a balanced swing frame in which the emery wheel is carried. The stone can be tilted to suit the shape of the saw teeth and is fed to its work by hand.

Automatic knife-grinding machine.—With this machine, the knives to be ground are bolted to a carrier having a canting adjustment, and fitted to a traversing table which brings the knife in contact with an emery stone along its entire length. The headstock and emery wheel may be mounted, and the stone fed towards the knife by means of a balance weight, or inversely the stone may be fixed and the knife brought to the stone by the carrier to which it is bolted.

Band saw filing and setting machine (small saws).—Compared with hand filing and setting of small band saws, an automatic machine saves considerable time and will deal with up to about 80 teeth per minute. The machine is so designed that the teeth are fed up to a taper file which does the sharpening whilst an automatic setting tool introduces the set. There are several modifications of this machine available.

Band saw brazing clamp (small saws).—This is a simple little apparatus used for exerting pressure at the joint during the process of brazing the ends of a band saw. The ends of the saw to be brazed together are bevelled to form a scarf joint. The joint is cleaned and a flux applied, together with a brazing agent, which is brought to melting point when the clamp is brought into operation on the joint.

Cutter balance.—To produce good results and to assist towards avoiding chatter, the cutters or knives on any single cutter block should be prefectly balanced, and, in planing machines, must have their weight evenly distributed along their length. The cutter balance is designed to enable the cutter grinder to detect errors in the balance of cutters and knives.

Emery wheels.—These wheels are made in a variety of shapes and grades for different types of grinding work. Good quality wheels free from flaws are essential, and they should not be driven at a periphery speed in excess of that laid down by the maker. Bad quality emery wheels may 'fly' and cause accidents, and too much care cannot be exercised when running emery wheels even of the best quality. Accidents are liable to occur through work being caught up between the emery wheel and the rest, through excessive pressure, the presence of flaws, or improper mounting.

Portable Sawmills

As the name implies, portable mills are specially designed for easy transport from one site to another as occasion demands.

The demand arises from the fact that where timber is difficult to transport in log form, or when transport costs from the forest to the market are excessive, it may be more satisfactory to convert the logs in the forest, transporting only the usable timber from the forest.

It naturally follows that, with continued felling and conversion, the forest compartment in which the mill is working becomes depleted of timber, and the mill has to be moved to fresh fields.

To facilitate transport, the mill must be as light as possible compatible with rigidity. Machines which can be taken to pieces are an asset, as these eliminate heavy one-piece lifts.

It is advisable to operate only with the simplest type of machines for forest work, as there is not usually an expert mechanic with equipment at hand to rectify stoppages peculiar to complicated machinery.

As the usual type of work engaged in by forest mills is slabbing and converting logs into sleepers, scantlings and beams, the machines required are not of so varied a character as those used in permanent mills, one or two break-down sawing machines and a couple of circular saw benches *plus* a tool room outfit, shafting, belting, pulleys, etc., being all that is necessary for most forest mills in India.

A portable steam engine which, in addition to driving the machines, can be used as a tractor for hauling machinery from site to site is invaluable for forest work. This engine should be capable of consuming wood refuse as fuel.

With regard to the choice of machinery, much will depend upon the class of work to be done and the output required. There are available at the present time rack benches, band saws, frame saws, cross-cut saws, saw benches, and tree fellers, all of a portable nature, and if properly run any of these machines will satisfy the requirements of an average forest mill.

Good foundations are essential for most high-speed woodworking machines, and it is advisable wherever possible to bolt machinery down to a cement concrete base. This is not really an expensive operation, and as it will eliminate vibration to a great extent, the machine output will be improved.

Where one machine only is employed, it is quite possible to drive this machine direct from the engine, but when several machines are to be driven off one engine, main shafting and possibly countershafting must be introduced. The diagram on page 214 depicts an idea for a semi-portable mill with a rack circular-saw bench for breaking down logs. As explained before, there is nothing hard and fast about mill designs, as every mill must be laid out to suit the requirements of the project in hand.

Some Sawing-Machine Troubles and How to Avoid them

With woodworking machinery it is almost impossible to foresee all circumstances which may cause bad results in output and quality. Most kinds of machinery have a tendency to get out of order, or to give poor returns, and woodworking machinery is certainly no exception.

To keep machines in proper order and to obtain the best possible results, the operators must not only know their machines, but must be prepared to meet any unexpected contingency which may arise and, if necessary, to introduce original improvisations for overcoming difficulties.

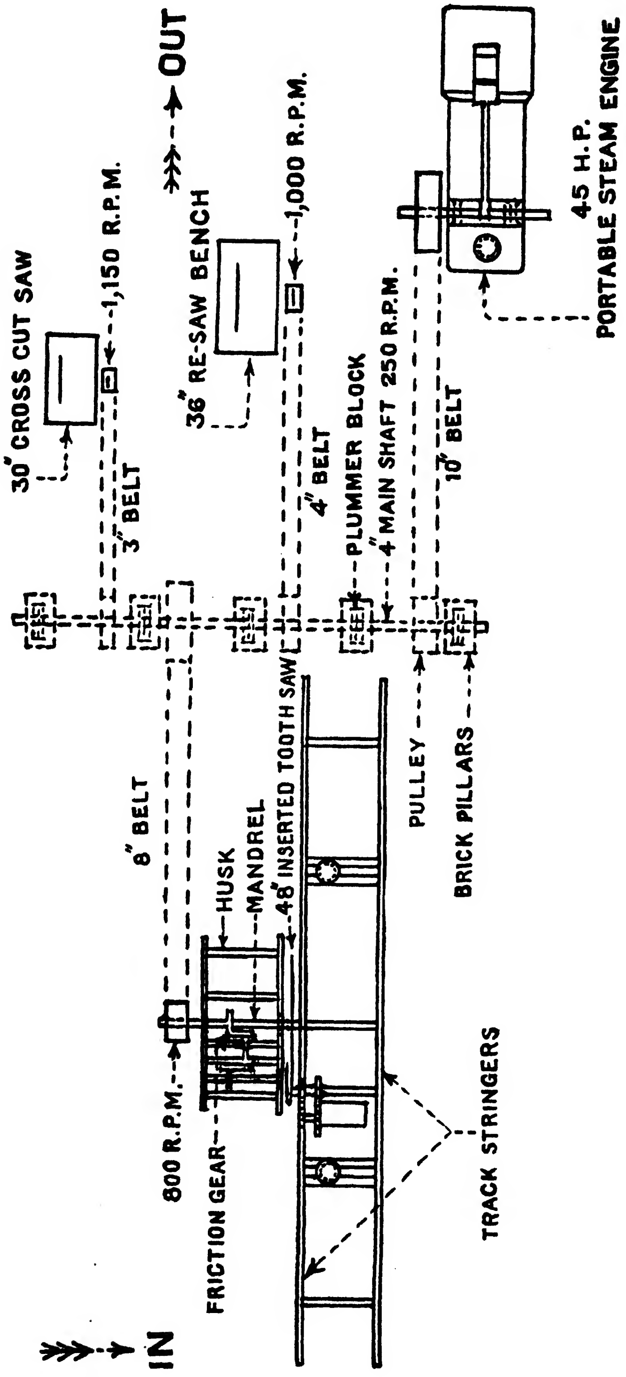


DIAGRAM 7. Lay-out for a semi-portable circular saw-mill

Trouble with sawing-machines may be due to one or more of the following causes:—

(1) uneven packing of the saw, (2) uneven sharpening and setting, (3) uneven tension, (4) tension too slack or too tight at the centre, (5) the pitch, packing, hook or gulleting not being suitable for the work in hand, (6) bad alignment of the carriage, (7) faulty bearings, (8) poor lubrication, bad quality of lubricant or the presence of grit, (9) imperfections in saw collars, (10) saw not balanced, (11) inattention to the correct hanging of saws, (12) belt slip or too tight belts.

Uneven or insufficient packing is a common reason for saws not running true. Packing should be done when the saw is in the bench, and must be so fitted that the saw runs steadily and slightly warmer at the centre than at the rim. Saw benches are generally supplied already fitted with packing receptacles. These take the form of two pieces of wood which are screwed or bolted to the underside of the finger plate on the one side and below the saw table on the other side of the saw. Both pieces of wood are rebated on the top edge, which allows for the insertion of hemp or other packing, which should be evenly bedded and without excessive pressure on both sides, and from the centre to the front of the saw. For the purpose of steadying and guiding the saw, it is a good practice to fasten two small pieces of felt or leather to the wooden packing pieces at the back, and near the rim of the saw. Many sawyers have sets of packing sticks which they keep by them for use with differently gauged saws. These consist of thin pieces of wood of a length equal to about half the diameter of the saw. The sticks are lapped from end to end with rope yarn, and when placed in position in the packing spaces, they should exert an even pressure on both sides of the front half of the saw plate, from the teeth to the eye, and should not protrude above the level of the table top. Saws should not be packed too tightly and lumps or knots in the rope yarn wrapping should be avoided. Lumps or any kind of unevenness in packing always causes uneven friction at the point of contact on the saw plate, which results in the saw running out of line.

If, after being properly packed, the saw continues to run out of truth, the teeth must be stoned until the saw is perfectly round, and the stone touches every tooth as the saw revolves. Then the teeth can be resharpened and set, and carefully re-packed. Should this treatment not give the desired results, the saw should be sent to the tool room for examination with regard to tension.

Speed of output within certain limits is, of course, one of the first considerations of the sawmiller. In attaining this, care must be taken to avoid overfeeding a saw beyond the limit compatible with good quality of cutting. This, together with an improperly adjusted saw fence, may cause a saw to run untrue. In

ordinary workshop practice, there appears to be very little reason for having a saw fence extended to more than 3 or 4 inches beyond the teeth at the front, as otherwise the wood will seize the saw, owing to its not having sufficient room to open out as it leaves the saw. In cutting large logs, or springy timber which closes in on the saw plate during conversion, wooden wedges should be used in the kerf at the take-off end of the bench to give extra clearance to the saw, and so prevent jamming and buckling.

All bearings should be kept free from grit and dirt, and only a good quality lubricant should be used on them. They should not be screwed up too tight, but tight enough to prevent play. End play on spindles must not be tolerated. Should a bearing continue to run hot, after ordinary precautions have been taken, the best remedy is to take it down and have it trued up. As a rule, any heat which is generated at the bearings of a saw spindle will be transmitted to the saw and give trouble.

The necessity for keeping saws in perfect condition cannot be too strongly emphasized, as this is one of the main secrets of successful conversion. A brief outline of the methods employed in saw sharpening, levelling, and tensioning may be found useful and is given below.

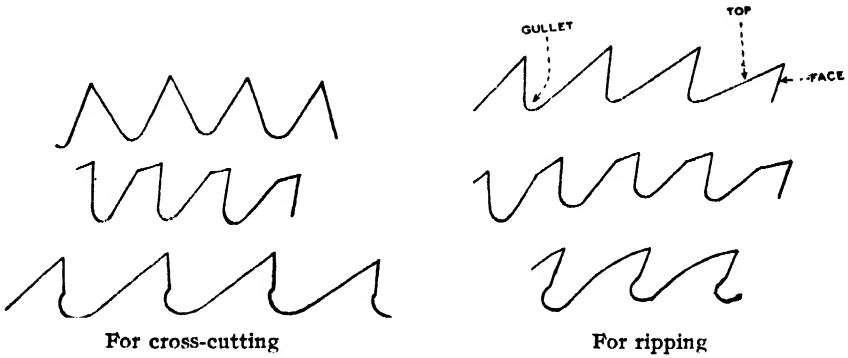


DIAGRAM 8. Typical circular saw teeth

There are many forms of saw teeth, and it is common knowledge that practical millmen have their own ideas as to what constitutes the best type of teeth for any particular timber or class of work. In general, it may be said that teeth intended for ripping timber have a forward rake or hook, whilst those for cross-cutting are not given any hook.

Whatever type or shape of tooth is used, the teeth must be kept sharp and, in the case of rip saws, properly set. The body of the saw must be free from

lumps and properly tensioned and the saw must run constant at the speed for which it is tensioned.

Every tooth in a circular saw, except novelty saws, must be of the same shape and height, and whichever style of set is employed, this set must be uniform.

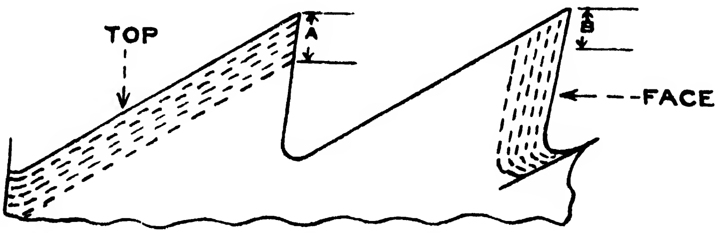
It is not good practice to 'top' a saw, i.e. to sharpen it by filing the tops of the teeth whilst the saw is hung on the mandrel in its bench. This practice will reduce the gullets to an extent sufficient to give poor conversion returns both in output and quality, and may do considerable damage to the saw plate.

The function of the gullet is to collect and carry the sawdust out of the cut. The gullets of each saw should be sunk to one common depth, this depth being governed by the feed speed and kind of timber being converted, timbers of a soft variety requiring bigger gullets than hard woods.

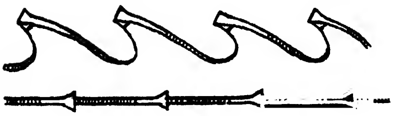
It will thus be seen that by 'topping' teeth the size of the gullet is reduced, and the gullet should be deepened to the same extent that teeth are reduced at each time of sharpening.

To do this, the saw should be removed from the saw bench and mounted on a saw-sharpening machine fitted with an emery disc adaptable to gulleting. The machine can then be set to bring all gullets to the same depth.

By applying the emery wheel to the face of the teeth, the same machine will do the sharpening, a light touch of a file being given to finish off.



Sharpening on top and face



Swage set

Spring set

DIAGRAM 9. Sharpening and setting of saws

Diagram 9 shows how sharpening saw teeth by face filing is more economical than top grinding.

Saws can, of course, be sharpened and gulleted by hand filing, but this is a slow process, and the results are not usually so uniform as those obtained by

machine sharpening. It is usual before commencing to sharpen a saw to bring all teeth to a common height.

Care must be taken to avoid too much pressure when using emery wheels, as this will result in bluing or burning the metal.

Except that with frame saws and band saws teeth must be kept in a straight line, the sharpening procedure for these saws is more or less the same as for circular saws.

Set is given to the teeth of saws to provide clearance for the saw as it passes through the cut, and is so arranged that the kerf produced is wider than the thickness of the saw plate, which prevents the timber binding on the body of the saw.

There are in common use two forms of set for saw teeth, spring set and swage set. With the former, the cutting point of each alternate tooth is bent over to the right and left, and with the latter, the cutting points are splayed to a width in excess of the thickness of the saw plate.

When applying spring set, either one-handled or two-handled saw-sets are used, as well as a saw-set gauge.

Saw-sets are fitted with slots to accommodate various gauges of saws. The required slot is passed over the teeth to be set, and the teeth are then levered over to right or left as the case may be to the desired amount. A check is made, by means of the saw-set gauge, to make sure that all teeth have received the same amount of set.

There are several ways of introducing swage set to saw teeth, and nowadays there are mechanical appliances for this purpose which require little skill to handle and give good results. These are the swage tool and side dresser. Teeth for swaging must be of a suitable shape, and the point must be of an acute angle to swage out easily, but must at the same time be strong enough to stand cutting strains. Bevel is not applied to this form of tooth, which should be made square across the points, as otherwise the saw will probably 'run' in the cut. Swaging is usually a little overdone to allow for side dressing, and the corners of the teeth are trimmed to make them uniform. Provided that swaging has been properly done, a saw can be resharpened a few times before it requires re-setting. Compared with a rip saw, a cross-cut saw requires very little set.

Saw teeth should have the right set and hook for the timber being cut, soft wood as a rule requiring more set than hard wood. A swaged saw, although probably requiring more power to drive, will do faster cutting than a spring-set saw. Teeth which are too high at their backs may cause a saw to seize and heat at the rim. In addition, the formation of square corners at the base of saw teeth may cause a saw plate to crack, and for this reason, and also to give greater dust space, the gullets should be kept round.

The quicker timber is fed to the saw, the lower the back of the teeth should

be. The number of teeth a saw should have is more or less governed by the gauge of the saw, the kind of timber to be sawn (usually more for hard woods than for soft woods), and also by the speed and feed at which the machine is being worked.

If a saw heats at the rim, it is due, probably, to either one or more of the following causes: (1) saw not open enough at the body, (2) insufficient throat room for dust, (3) backs of teeth too high, (4) gum and resin on the teeth, (5) guide pins too close, (6) insufficient set.

A saw may become heated at its centre on account of (1) the mandrel running too warm, (2) insufficient set, (3) saw too open at centre, (4) speed too low to expand the rim, (5) saw lined too much out of the log. A saw should run at the same speed when cutting as when 'idling', i.e. running free. The holes in a saw should be an easy fit on the steady-pins and mandrel, and end play should be avoided.

To obtain a good running saw, the collars and stem of the mandrel must be true and well fitted, as any irregularities in the collars will be multiplied many times at the rim of the saw. Collars should be concave or recessed from the centre up to about an inch from the rim, which should have a perfect bearing on the saw plate. The stem of the mandrel being true, the hole or eye of the saw should be just large enough to allow the saw to slip easily up to the fast collar and steady-pin. Before hanging a large saw, it is as well to test it with a straight-edge and, if it is true, the saw can be placed on the mandrel and the collars securely tightened. Another test with a straight-edge should then be made to ascertain if the saw has been thrown out of shape, and if so, the fault will no doubt be in the collars, and damage to the saw may ensue if it is allowed to run in this state. Many difficulties due to the collars may be overcome by the introduction of paper washers. If the saw is 'dished' on the side nearest to the log when cutting, a ring of paper of the size of the collar and about three-quarters of an inch wide may be cut. This paper ring should be moistened with oil and can then be placed on the loose collar. A smaller ring of paper of the same width should be made to fit the mandrel and should be placed against the fast collar. Should one thickness of paper not be sufficient, further rings can be added until the saw becomes true when tightened up between the collars. A saw which is 'crowning' on the log side should be treated in a reverse manner to a 'dished' saw; the larger paper rings being placed against the fast collar and the smaller ones next to the loose collar.

As uniformity in speed of saws is an important factor in producing good output, the following table of speeds should be followed:—

Diameter of saw	Revolutions per minute	Diameter of saw	Revolutions per minute	Diameter of saw	Revolutions per minute	Diameter of saw	Revolutions per minute
18 inches	2,000	28 inches	1,285	38 inches	950	48 inches	750
20 ,,	1,800	30 ,,	1,200	40 ,,	900	50 ,,	725
22 ,,	1,636	32 ,,	1,120	42 ,,	870	52 ,,	700
24 ,,	1,500	34 ,,	1,050	44 ,,	840	54 ,,	675
26 ,,	1,384	36 ,,	1,000	46 ,,	800	56 ,,	650

Rules for calculating the speeds of pulleys and saws

(1) If the diameter of driving and driven pulleys and the speed of the driver are given, the speed of the driven pulley is calculated as follows:—

> Multiply the diameter of the driver by its number of revolutions, and divide the result by the diameter of the driven pulley.

(2) If the diameter and revolutions of the driven pulley are given, then the diameter of the driver is calculated as follows:—

> Multiply the number of revolutions of the driven pulley by its diameter and divide the product by the number of revolutions of the driving shaft.

The levelling and tensioning of saws is a difficult craft, the art of which is only acquired after considerable experience coupled with judgement and skill. In other words, it is a specialist's work, and unless a mill can afford to maintain a saw doctor it is better not to attempt tensioning, but instead to send such saws as require attention to the makers or to some other mill which has a saw doctor.

When a circular saw is in tension it should, when raised from the anvil, fall away between the collar and the teeth so that when a straight-edge is placed across the plate from the collar to the teeth a curve should be observed. Band reciprocating saws should show a curve between the teeth and back of the blade.

Conversion

In machine sawing, considerable skill is required to convert logs economically into a good quality marketable product with the least waste, and as no definite rules can be laid down for this operation, a great deal depends upon the experience and judgement of the sawyer.

Each log must be studied, and the style of product required must be considered carefully before a cut is made, as a particular method of conversion may be economical for certain sizes of timber but not for others.

Nature too, particularly in the case of many Indian species, is not over-generous in the matter of providing clean healthy straight boles of cylindrical timber, which factors, to a great extent, govern conversion methods.

Excessive taper, flutes, heart and other shakes are causes of conversion difficulties which have to be considered, and waste must be reduced as far as possible by judicious sawing. For example, boles which have shakes throughout their length would possibly give a very poor return if sawn into planks and all the planks may be affected by the shakes, whereas, by studying the lie of the shakes, a fair percentage of scantlings or similar material might be obtained.

It is not assumed that the average mill converts timber with an eye to obtaining the best 'figure', but, should figure be required it can be broadly stated that most timbers present the richest figure when radially sawn.

With unfigured timbers, or for work like sleepers and scantlings where figure is not a consideration, the quicker and more simple method of tangential sawing is practised.

To avoid shakes it is advisable to convert logs as early as possible after felling.

Part III

UTILIZATION OF MINOR FOREST PRODUCTS

INTRODUCTION

The term 'minor forest products' includes all kinds of forest produce other than timber and firewood. Minor forest products comprise all animal, vegetable, and mineral products found in forest areas, and, in consequence, vary very considerably in kind as well as in value.

For convenience sake, the minor forest products of India may be divided into the following classes:—

(1) Fibres and flosses.
(2) Grasses (other than oil-producing grasses), bamboos, and canes.
(3) Distillation and extraction products (including oil-yielding grasses).
(4) Oilseeds.
(5) Tans and dyes.
(6) Gums, resins, and oleo-resins.
(7) Drugs, spices, edible products, and poisons.
(8) Animal, mineral, and miscellaneous products.

It must be clearly understood that, in a Manual of this kind, it is only possible to touch the fringe of the vast wealth of minor forest products which India possesses. The magnitude of this wealth can be realized from the fact that the value of the minor forest products extracted from areas under the control of the Forest Department reached the enormous total of over Rs1,51,00,000 in the year 1928-9, while the estimated value of the minor forest products (including grass and grazing) given away free, or at reduced rates, totalled nearly Rs47,00,000.

These figures do not, however, represent the potential revenue to be derived from minor forest products. The present methods of collecting and marketing these products are, in many cases, extremely crude, and an improvement in this direction would undoubtedly lead to an increase in revenue, while there are still countless products which are not now extracted and are left to go to waste, as they are, at present, of no known use.

Minor forest products, apart from their monetary value, are also of enormous economic value to India as a whole. Consider, for instance, the value to agriculture of the grazing and fodder afforded by forest areas. India is an agricultural country, but one in which agriculture has not yet been brought to a state of efficiency. Rarely, if ever, is it the custom to grow fodder crops to feed the cattle on which agriculture is absolutely dependent, and the ryot, as often as not, relies solely on the forests for grazing and fodder for the numerous cattle which

he usually owns. It is true that the better bullocks used for ploughing, etc., are often stall-fed, but the cows from which he obtains his milk and on which he is dependent for breeding, are driven to the forest daily to obtain their livelihood. On the forest, too, he depends for the bamboos with which to build his house and cattle-sheds, for grass for thatching, for fibre for ropes, for oils for cooking and burning, and for many other products too numerous to mention, while he is often dependent for relief in cases of sickness on medicinal plants which the forest supplies.

It is not necessary to stress these points, but in estimating the value of the minor forest products too great significance should not be attached to their monetary value to the exclusion of a proper understanding of their true economic importance.

It has been mentioned above that the figures quoted do not represent the potential value of the minor forest products, and a few words in support of this statement will not, perhaps, be out of place.

The collection and marketing of these minor forest products are, for the most part, in the hands of petty contractors, who purchase the right to collect these products from reserved forests, many products, as often as not, being included in one lease. These contractors collect those products for which they can find a ready sale, through the agency of forest tribes and villagers living in the vicinity of the forest. The latter collect and prepare these products in the manner which has been handed down to them by their forbears. Such methods of collection and preparation are often very crude, while due attention is not paid to the real requirements of the market. The products are then sold to larger dealers, and often pass through many hands before they eventually reach the consumer or shipper. During this period they are subjected to adulteration either wilfully or in the ordinary course of handling, while they also frequently deteriorate owing to faulty methods of storage. It is apparent, therefore, that it is often an inferior article which eventually reaches the consumer.

What is required is an improvement in the method of collection and preparation and the placing of the collector or producer in closer touch with the consumer. India is, however, very conservative, and any attempt at improving the methods of collection and preparation should, in most cases, be directed towards an improvement of the existing 'country' methods rather than towards the introduction of up-to-date machinery, which, more often than not, is not properly understood or is misused. It is along these lines that the efforts of the Minor Forest Products Section of the Forest Research Institute are being directed, but there are many difficulties to be overcome, and even after considerable knowledge of any forest product has been obtained as the result of research or experiment, there still remains the difficulty of bringing this knowledge to the

person really concerned, namely the actual collector of the produce. Research has already brought to light many uses for products which were at one time considered to be valueless, but there is still endless work to be done in this direction, and it is probable that the true value of many minor forest products will not be obtained until they are collected departmentally under adequate supervision. The Forest Department, however, is not yet in a position to undertake work of this kind, except in the case of a few of the more important products, being at present too busily engaged in the extraction of timber and firewood, but as time advances the minor products of India's forests will undoubtedly receive greater attention, and even in the present times there are indications that improvements have already begun.

XI

FIBRES AND FLOSSES

FIBRES

FROM STEMS; *Sterculiaceae—Tiliaceae—Linaceae—Leguminosae—Asclepiadaceae—Urticaceae.* **FROM LEAVES; kitool—manilla hemp—screw pines—aloes.**

FLOSSES

Kapok—Indian kapok—coir.

FIBRES

FROM STEMS

Fibres are obtained from the bast tissue of many woody species, some of which yield long strong fibres suitable for twisting into ropes, whereas others yield silky fibres which are fine enough for textile purposes.

The methods of extracting the fibres vary considerably with different species, but the process of separating the fibres from each other is technically known as 'retting'.

Retting is a most important process in the preparation of most fibres, and consists essentially in submitting the stems of the plants to the action of water and allowing fermentation to take place. This effects the conversion of insoluble gummy matter into soluble substances which are removed by the water, thereby softening the tissues, the fibres afterwards being beaten and scraped clean.

The process of retting is usually carried out either in pools or in running water, and the time required for retting varies with the age of the plants, the temperature of the water, and with other conditions, and may last from a few days to a month or more. Over-retting weakens the fibres and spoils their lustre, while under-retting results in part of the gummy matter being retained, thereby making the separation and proper cleaning of the fibres difficult. On the other hand, there are certain fibres which are used without any retting at all, just as they come off the tree, and there are others, for example those of *Calotropis gigantea,* which are rendered useless if immersed in water.

There are a very large number of bast fibres to be found in Indian forests, but only a few of these have any great commercial value, the majority being of local value only. From a financial point of view, therefore, these fibres are unimportant, but from an economic point of view they are very often indispensable. The Forest Department especially is largely dependent on these fibres

for making ropes for draglines and rafting, and villagers use them extensively for their bullock harness and ropes.

The majority of plants yielding useful fibres belong to the families *Sterculiaceae*, *Tiliaceae*, *Leguminosae*, *Asclepiadaceae*, and *Urticaceae*. The more important of these are the following:—

Sterculiaceae

Sterculia villosa.—This species is common throughout India and Burma. It yields a coarse, strong, whitish-pink fibre which strips off the tree in long broad flakes which have a peculiar net-like appearance. The fibre is used extensively in Madras, Burma, and Bengal, for making elephant harness and drag-ropes, and for tying rafts, and throughout India for making bags and ropes for all purposes. Rope made from this fibre is said to become stronger, for a time, from being frequently wetted, but it seldom lasts more than 18 months if constantly exposed to moisture.

Sterculia urens
Sterculia foetida
Sterculia colorata
} All yield rope fibres, but they are not so sought after as the fibre of *Sterculia villosa*.

Helicteres isora.—A very common shrub found in the drier forests of India and Burma. It yields a light brown or greyish fibre which is not so coarse as the *Sterculia* fibres. It is soft and silky, but is rather lacking in strength. It resembles China jute, but is considered to be inferior to Bengal jute although it is more durable. The bast is difficult to separate from the bark, and therefore requires longer soaking in water and more careful retting before it can be used for rope-making. It is used for sacking and for tying up rice-bundles in South India, for sewing up gunny bags and for cattle harness. Attempts have been made to improve the quality of this fibre by extracting it from even-aged coppice shoots and by careful retting, but these attempts did not meet with much success. In Travancore and Madras it is an important local product and is the chief material for making sacks and bags. It has the reputation of lasting twice as long as jute, and sacks and bags made of this fibre are often good after 5 years' use, whereas a jute bag seldom lasts more than 2 years.

Tiliaceae

Grewia tiliaefolia
Grewia vestita
Grewia laevigata
Grewia oppositifolia
} All yield coarse strong yellow-brown fibres, which are used locally for rope-making and domestic purposes.

Corchorus capsularis
Corchorus olitorius
} Cultivated plants, which are not important from a forest point of view, but which yield the

well-known jute of commerce. Jute is a true bast fibre consisting of fibro-vascular bundles. The plant, which is an annual, is cultivated extensively in India, the most important jute areas being in Assam, Bengal, Bihar, and Orissa. Its great prominence as one of the most important commercial products of India is due to its being the cheapest and most easily manufactured of all fibres, and the stimulus which caused its extensive cultivation was the growing demand for a cheap container for rice and other food supplies, resulting in the well-known gunny bag of India.

Linaceae

Linum usitatissimum—the flax plant. This plant is extensively cultivated in Europe for its valuable fibre, which is used for the manufacture of linen. In India, it is chiefly cultivated for the well-known product linseed oil, which is obtained from the seeds, experiments having shown that the Indian climate is, on the whole, unsuitable for the production of a fibre of a quality good enough for textile purposes. Recent experiments have, however, shown that the Indian fibre makes an excellent paper pulp material. It is of high quality and very suitable for the manufacture of badami and wrapping papers. The possibility of combining the production of linseed with that of flax has been a subject of investigation on many occasions during the past 100 years, but almost invariably the production of high class seed has resulted in the fibres of the stem proving useless, and vice versa. As India appears to be more suited to the production of good linseed, the Indian cultivator rightly goes in for the growing of *Linum* for its seed rather than for its fibre, although the fibre is in some districts grown with success and exported.

Leguminosae

Hardwickia binata.—A fairly common tree in Madras, Bombay, and the Central Provinces. The fibre is obtained from the branches and especially from the young shoots. It is of a red-brown colour and fairly strong. It strips off in narrow bands, but has an untidy appearance due to the short lengths in which it comes away. It is used chiefly for cordage and rope-making. The tree is often pollarded to produce young shoots which yield a superior fibre to that produced by the stem.

Spatholobus roxburghii
Bauhinia vahlii } Fibre-producing climbers commonly found in most Indian forests. They are usually looked upon as forest pests, owing to the damage they do to healthy trees by climbing all over them, but they have the redeeming feature of yielding valuable strong rope fibres which are used extensively for tying up faggots, and for other

forest work. *Spatholobus roxburghii* fibre is also used commonly in Malabar for tying up rice-bundles called *mundis*.

Amongst other fibre-yielding trees belonging to this order are **Ougeinia dalbergioides**, **Acacia leucophloea**, **Bauhinia racemosa**, **Butea frondosa**, and **Millettia auriculata**. The commercial product known as sunn-hemp is obtained from **Crotalaria juncea**, a plant which is extensively cultivated throughout the plains of India and Burma. It is greatly favoured in some districts as a weed-exterminator and soil-improver, and from a forest point of view is of interest as being a profitable plant to grow in *taungya* plantations. The fibre is used chiefly for cordage and canvas and when tanned is very durable under sea water, and consequently sunn-hemp is used throughout India for fishing nets, and as a substitute generally for true hemp. The yield of stems per acre is about 3 or 4 tons, which gives 5 or 6 cwt. of cleaned fibre.

Asclepiadaceae

Calotropis gigantea
Calotropis procera
Two common shrubs yielding valuable fibres. Generally found in dry tracts and in sandy river-beds in the Punjab, Sind, Rajputana, the Central Provinces and Burma. The fibre is fine, white and silky, very strong, and durable under fresh and salt water. It is one of the strongest fibres known, and a rope made of this fibre took a strain of 407 lb. while a cotton rope of the same size and shape broke at 346 lb. It is used extensively for making fishing nets, fishing lines, bow-strings, and twine. The fibre cannot be retted as it rots when so treated and it is, therefore, difficult to separate rapidly and cheaply. This usually has to be done by hand, which is a slow and expensive procedure and has been the chief drawback to the more extensive cultivation and use of this fibre.

Marsdenia tenacissima.—A climbing shrub found in the sub-Himalayan tracts and in Chittagong and Upper Burma. It yields an exceptionally strong fibre which is used for bow-strings, netting and cordage, and has been described as the second best fibre in India, but being a climbing shrub it has never been popular.

Urticaceae

Ficus cunia
Ficus religiosa
Ficus bengalensis
Common trees yielding short strong fibres which are suitable for ropes. The last two are somewhat inferior to *Ficus cunia*, but as the trees are usually very scattered they are not of great importance from a fibre point of view.

Boehmeria nivea.—Yields the well-known rhea or ramie fibre, which is a fine white fibre used in commercial rope-manufacture, and commonly sold under

the name of China grass. It is not, however, a true forest product, as *Boehmeria nivea* will only grow under proper cultivation. It has been suggested as a suitable subject for *taungya* cultivation, but it will not grow in some types of soil and it needs manuring and good cultivation. The fibre has in addition to be decorticated by machinery and this is not always possible in or near forest plantations.

Cannabis sativa (*bhang*).—The true hemp of commerce. When cultivated it produces a superfine white fibre used for the manufacture of ropes, cables, twine, mats, sail-cloth, canvas, and tarpaulins. It is also a plant found as a weed of cultivation and common near cattle-sheds and village rubbish-heaps. It is also found in forest areas on old cattle stands and camping grounds. In tropical countries it is not appreciated as a fibre, but is sometimes cultivated for the narcotics which it yields. Information on this subject will be found on page 298 under Drugs.

From a forest point of view therefore, hemp is not an important subject, as the wild plant is useless or nearly so and even the forest villagers make small use of it.

Trema orientalis.—A shrub or small tree found in most plains' forests of India. It yields a long light-brown fibre which strips off the tree in thin narrow bands which are easily separated after drying, and are used for making ropes, twine, and coarse cloth.

Girardinia heterophylla (the Nilgiri nettle).—A tall, stout, erect herb from 4 to 6 ft. high, common in the temperate and sub-tropical Himalayas, ascending to an altitude of 5,000 ft. It is also met with in Assam, Sylhet, and Burma, and extends from Central India to Travancore and Ceylon. This herb produces a fine soft silky fibre which is used for making ropes, twine and thread, and a coarse cloth like gunny. It is not of great commercial importance, owing to the difficulty of properly cleaning and de-gumming the fibre, and the cost of collection.

Attempts have been made from time to time by the Forest Department to collect and market this fibre at economic rates, but they have usually ended in failure. It was found that it was necessary to collect 27 to 30 maunds of bark in order to produce one maund of clean fibre, and the cost of collection and preparation of the fibre seldom came to less than Rs60 per maund, which was a prohibitive figure.

Other fibre-yielding trees of this family are other **Boehmeria** species and **Antiaris toxicaria**, which produces a net-like fibre, stripping off in large sizes so that, by sewing up one end and side, a complete bag is obtained ready for use. **Broussonetia papyrifera** (paper mulberry), and **Streblus asper** produce white fibres which are used for local hand paper-making in some districts.

Fibre-producing species amongst other families are not very numerous. **Careya arborea**, a common tree found in most moist deciduous forests, yields a fibre in broad bands, used for cordage, tying carts and rafters, and in Burma, for putting under elephant saddles. **Cordia myxa** and **Cordia rothii** both yield bast fibres, used for caulking boats and for rope-making. The leaves of the former are also much prized for making the outer coverings of the well-known green Burmese cheroots. **Kydia calycina** also produces a good strong fibre, sometimes used for making elephant drag-ropes. Amongst others, of local importance only, are *Thespesia populnea, Moringa pterygosperma, Albizzia odoratissima, Erythrina suberosa, Lannea grandis, Cerbera odollam, Miliusa velutina, Berrya ammonilla,* and *Urena* spp.

From Leaves

Kitool

One of the most important of the fibre-producing leaves are those of **Caryota urens**, the Indian sago palm, which yields the well-known kital or kitool fibre of commerce. This palm is found in the moist forests of Assam, Bengal, Orissa, Madras, and Burma. The fibre is of considerable value, being strong and of fair length. The colour is a dusky brown to black, and the fibres are straight, smooth, and very elastic. It is used by fishermen in preparing their nets and fishing lines. It is also used in short lengths as bristles for brushes and is a useful rope-making fibre. As a material for soft brooms, either alone or mixed with bristles, the fibre is used extensively, but is previously softened by steam and treated with linseed oil. It is not exported from India to any great extent, but a considerable quantity is exported from Ceylon and Malay.

Manilla hemp

Another commercially important leaf fibre is that of **Musa textilis,** a Philippine Island plant, cultivated in India, and yielding the well-known Manilla hemp. **Musa sapientum**, the common plantain, and **Musa paradisiaca,** the red plantain of Bombay, also yield strong fibres but, from a forest point of view, these plantain fibres are not important, as they are not sufficiently plentiful to make their collection profitable.

Screw pines

Pandanus spp.—The leaves of these plants produce a useful strong fibre for cordage, fishing nets, fishing lines and sacking, and the aerial root fibres are split by beating, and are cut into short lengths for brush bristles. The best known is **Pandanus odoratissimus**, a common shrub or small tree in the tidal forests of the Sunderbans and Burma. It is also found in the Andamans and on the West Coast.

Aloes

Agave angustifolia
Agave cantala
Agave lurida
Agave sisalana

The well-known aloe plants of India. All yield fibres of varying utility, **Agave sisalana** producing the sisal fibre of commerce. The *Agave* species are only interesting from a forest officer's point of view because they are extensively used in many districts for demarcation purposes and live hedges, and the fibres obtained from their leaves yield a certain amount of revenue. *Agave* plants are also frequently seen demarcating railway lines and roads. Sisal fibre has come into extensive use of late years, but the production of this fibre in India is not great, though it has frequently been made a subject of commercial enterprise. Extensive plantations have been started in Bihar. These fibres cannot be separated by retting. The fleshy pulp is scraped away by hand, or by special machines, and the fibres are then washed and dried in the sun.

An account of fibre-producing grasses found in India will be found in the next chapter.

FLOSSES

There are several forest trees and plants in India which produce silky flosses in their fruits.

Kapok

These tree flosses are known commercially as tree cottons, silk cottons or kapoks. They are usually too short to be used for spinning or weaving, but are used extensively for upholstery work and for stuffing life-belts, pillows, mattresses, and *rezais*. The true kapok or white silk cotton tree is **Eriodendron anfractuosum**, a moderate sized tree found in the west and south of India and in Burma, but it is probably not indigenous except possibly in the Western Ghats. It is really a Java species and is found also to a lesser extent in Ceylon. In India it is often found planted round villages and temples. The floss produced by the fruits of this tree is of very good quality, being more elastic and not so liable to 'bunch' when used in upholstery as other flosses found in India. It is extensively used abroad in the manufacture of life-belts and buoys owing to its extreme buoyancy and resistance to waterlogging. The main supplies come from Java.

It is used locally in India to a small extent, but is not exported in any large quantities from India, although it fetches a far higher price than other kapoks.

Indian kapok

The kapok which takes precedence in India, on account of its abundance, is that of the semul or cotton tree, **Bombax malabaricum**. The capsule of this

tree yields a silky cotton, not very long but soft and strong, and known all over the world as Indian kapok. Actual tests conducted by the Imperial Institute as well as by the Admiralty have shown that Indian semul (*Bombax malabaricum*) floss is in no way inferior to the true Java kapok (*Eriodendron anfractuosum*) for use in life-saving appliances at sea. They only show that it is likely to be adulterated with the much less useful *akund* floss (*Calotropis* spp.). The semul tree is very common in most parts of India, and its floss now holds first place in the Indian kapok markets and is exported in large quantities from this country. The capsules should be collected green, as the floss loses much of its resilience after the capsules have opened.

There are two other plants producing kapoks of minor commercial importance, namely **Cochlospermum gossypium** and **Calotropis gigantea**.

The former, known locally as the *guneri* tree, is found in the United Provinces at low elevations, in Central India and Burma. *Calotropis gigantea* is a small bush found in the sub-Himalayan tract of the United Provinces, Sind, Central India, and in the drier regions of South India and Burma. It produces a fine silky floss, and is used extensively in the United Provinces for stuffing mattresses and pillows. What is sold in the bazaar as *semal ka ruye* is mostly *Calotropis* floss. The Imperial Institute in England reported most favourably on it some years ago.

There are many other floss-producing plants of local importance only, including *Calotropis procera*, *Holarrhena antidysenterica*, *Wrightia tomentosa*, *Cryptolepis buchanani*, *Salix daphnoides*, *Populus ciliata*, and *Beaumontia grandiflora*.

Coir

The well-known coir fibre, used extensively all over the world for mats, brushes, ropes, and other purposes, is not a true bast fibre or true floss, but is obtained from the thick fibrous husk of the fruit of the coconut palm, **Cocos nucifera**. Coir fibre is coarse, stiff, buoyant, and elastic and is, therefore, very suitable for the manufacture of ships' ropes, especially as the fibre is strengthened by the action of sea water.

XII

GRASSES,[1] BAMBOOS, AND CANES

GRASSES; *bhabar* or *baib* grass—*munj*—*ekra*—khus-khus—thatching grasses—other grasses. BAMBOOS; male bamboo—other species. CANES.

GRASSES

The utilization of grass is, from a forest point of view, one of the most important questions connected with forest work in India.

When one realizes that the Forest Revenue from grass and grazing amounted to the enormous total of Rs77,00,000 in 1928-9, while the estimated value of the grass and grazing given away free or at reduced rates was over Rs22,00,000, it will be understood that the above remark is not exaggerated. It is not intended to consider grazing at this juncture, as a special chapter is devoted to this subject, but as grasses are used in India for a very great variety of purposes other than grazing, it is these uses which will now be considered.

In the first place, there are no grasses in India which supply really fine textile fibres, but there are several grass fibres which are very suitable for cordage and matting. The two most important in this respect are *bhabar* or *baib* (*Ischaemum angustifolium* syn. *Pollinidium angustifolium*) and *munj* (*Saccharum munja*).

Bhabar or baib grass

Ischaemum angustifolium syn. Pollinidium angustifolium produces the common *bhabar*, *baib*, or *sabai* grass found on the bare slopes and forest blanks of the sub-Himalayan areas. It is also common in Bihar, Orissa, Bengal, Central India, and the east of the Punjab, and extends even into Afghanistan. Its chief use is for paper-making, and in this respect it holds first place in India at present, as over 40,000 tons of this grass find their way annually to the Indian paper mills. It is usually bundled and pressed *in situ* and loaded in this form onto railway trucks, to be conveyed direct to the paper mills. The *bhabar* grass area of India at one time began to fail to meet the increasing demands of the paper mills, and this grass was collected from places which were, in some cases, more than 900 miles from the factories. Owing to the increasing demand,

[1] Other than oil grasses.

its cultivation was taken up both by the Forest Department and by private individuals, especially in Orissa and Bihar, but the demand has lessened considerably of late years owing to the more extended use of bamboos for paper-making and the very large reduction in the price of imported pulps. The principal localities supplying grass to paper mills are Bengal, the United Provinces, Bihar, Orissa, the Central Provinces, and the Nepal terai. *Bhabar* grass is also used for making rough ropes and mats, and there is an extensive manufacture of *bhabar* mats at Shahjehanpur in the United Provinces, these being known commercially as Shahjehanpur matting.

Munj

Saccharum munja, known all over India as *munj* grass, is found almost throughout India, along river-beds and in other low-lying places of the plains and lower hills. In the Punjab it covers large tracts of country. It is a reed-like grass with a straw-coloured long straight stem. The fibre, obtained from the leaf-sheath, is extensively used in the manufacture of cordage and ropes, and for the well-known Delhi matting. *Munj* matting is strong and has a wonderful power of enduring moisture without decaying. It is fairly proof against white ants, but they do attack it when it gets old. The blades of the leaf are used for thatching in some parts of India and also for the manufacture of paper, while the flowering stem is used for thatching boats, carts, etc. The lower and stronger portions of the flowering stem are used in the manufacture of chairs, stools, tables, baskets, and screens.

Ekra

Ekra grass, which is possibly a variety of **Saccharum spontaneum** found in Bengal and Assam, is used extensively in those provinces for making *ekra* mud walls, which are built up with mud plastered over this grass. In the early part of the year the old grass which is left on the clumps is burnt, and the young crop of new leaves produced in the hot weather is much sought after as fodder.

Khus-khus

Another important grass is **Vetiveria zizanioides** which produces the khus-khus of commerce. It is found throughout the plains and lower hills of India and Burma, up to 4,000 ft. on moist heavy soils, and along the margins of streams and lakes. Khus-khus is the name given to the long fibrous roots of this grass, which are used throughout India for making the well-known khus-khus tatties, or aromatic scented mats, which are hung over doorways and kept wet to cool the air of house and office rooms in hot weather. Khus-khus is also commonly used for the manufacture of fans, ornamental baskets, etc. The roots are

exported in fairly large quantities from Madras ports. The stems of this grass are used to a limited extent for paper-making, and the young grass is much used for fodder and extensively used for thatching purposes.

Thatching grasses

Other thatching grasses, used throughout India, and bringing in a certain amount of revenue, are **Heteropogon contortus syn. Imperata arundinacea, Saccharum narenga**, and **Erianthus ravennae**.

Thatching grass is usually cut as soon as it is mature, but if left uncut after it has matured it soon deteriorates by rotting. It should be cut regularly every year, as the clumps fall off in quality and quantity if left uncut for a season. If not cut it may be burnt over, which has the same restorative effect as cutting.

Other grasses

The only other plants of a grass type of any importance are: **Typha elephantina** (elephant grass), a reed used for ropes, baskets, and matting, which is also good as fodder and yields more per acre than any other fodder crop; **Cyperus tegetum** (*korai*), a sedge found in most parts of India and used for mat-making; and **Phragmites spp.** (the *sur* reed), found in marshes and swamps of North India and used for chair and basket making. When split open the reeds are woven into mats.

Mention may also be made of *Themeda gigantea* syn. *Anthisteria gigantea* (*ulla*), a large grass of the forest savannahs of Northern India, *Saccharum spontaneum* (*kans*) and *Desmostachys cynosuroides* syn. *Eragrostis cynosuroides* (*dab*). The fibre of these grasses is used to a certain extent for ropes and cordage. Recent experiments carried out at the Forest Research Institute indicate that they are likely to prove suitable for the production of cheap badami papers. Further experiments are necessary, however, to determine whether they will be suitable for the production of bleached papers.

BAMBOOS

The number of different species of bamboos found in India and Burma is very large, and over 100 species have already been identified. Some are restricted in their distribution, whereas others cover large areas forming pure bamboo forests; some are of almost universal utility, whereas others are of negligible importance. The revenue realized during 1928-9 from the sale of bamboos reached a total of nearly Rs19,00,000.

Male bamboo

The most common, most valuable, and most universally used of all Indian bamboos is **Dendrocalamus strictus**. It is the 'male bamboo' of commerce, although this trade term is usually applied to any more or less solid bamboo. It occurs throughout India and Burma, except in East Bengal and Assam, and is found usually on moderately dry hill slopes. On dry hills like the Siwaliks, Mount Abu, etc., many of the culms are quite solid, but in wetter places, as in Burma and in the valleys of South India, the culms are larger and have a distinct central cavity. It is used for a great variety of purposes, ranging from house posts to fountain pens. Amongst its most common uses may be mentioned rafters, scaffolding, roofing, walling, flooring, matting, spear- and lance-shafts, *lathis*, masts, spars, tent-poles, furniture, water pipes, cart shafts, basket-making, musical instruments, bows and arrows, and cordage. In Burma, it is the universal supply store of every villager, who not only uses it to build and furnish his house with, but also collects the young tender shoots and seed for feeding himself and his family. The male bamboo is exported to Europe in fairly large quantities, where it is used for lance-shafts.

Other species

Many other common bamboos found in India are also used for the above purposes, the following being the most important:—

Dendrocalamus giganteus.—The biggest of the Indian bamboos, found wild in Tenasserim, the Shan States, and the Malay Peninsula, and cultivated in parts of Burma, Assam, Bengal, and Malabar. It produces culms 8 to 10 in. in diameter and these, when cut into sections, are, in Burma especially, extensively used for water buckets and boxes.

Bambusa arundinacea.—The thorny bamboo, found growing wild and cultivated in most parts of India. It produces culms up to 100 ft. high and 6 to 7 in. in diameter. The culms interlace so much and are so intertwined with thorny branchlets that the extraction of separate culms is difficult. The thorny bamboo is, however, often used for rafters, house posts, ladders, tent poles, shafts of tongas and tum-tums, and for mat and basket making. The leaves are used as fodder.

Bambusa tulda.—This is the most common bamboo of Lower Bengal and also occurs in Assam, Chittagong, the Northern Circars, and Burma. It produces greyish-green culms 20 to 70 ft. in height and 2 to 4 in. in diameter, which are used for all general building purposes and in mat and basket making. The young shoots are sometimes eaten.

Bambusa polymorpha.—A large bamboo, reaching to a height of 50 to 80 ft. and a diameter of 3 to 6 in., met with in Eastern Bengal, in Sylhet, and in Burma. The culms are said to be the best in Burma for building purposes.

Arundinaria falcata.—The common lower level ringal found in the Western Himalayas from the Ravi to Nepal, at 4,000 to 7,000 ft., and in Bengal. The culms are used for basket work, hookah-tubes, fishing rods, etc.

Arundinaria spathiflora.—A small but useful bamboo found growing gregariously in undergrowth of fir, oak, and deodar forests of the Western Himalayas at an elevation of 7,000 to 9,000 ft. The culms are used for pipe-stems, baskets, pea-sticks, etc.

Oxytenanthera nigrociliata.—A tufted bamboo, with culms 30 to 40 ft. long and ½ to 2 in. in diameter, found in Assam, the Garo Hills, Chittagong, Burma, and the Andaman Islands, where it is gregarious. It is used in the Garo Hills for building and basket work and in the Andamans for making huts.

Oxytenanthera monostigma.—A slender bamboo of the Konkan coast and Ghats of North Kanara, where it is often cultivated. The culms are strong and are used for punt-poles and umbrella handles.

Cephalostachyum pergracile.—A tufted bamboo with culms 30 to 40 ft. high and 2 to 3 in. in diameter and rather thin-walled, the walls being about ½ inch thick. It is one of the chief bamboos of Burma, and one of those most frequently found in association with teak. The culms are used for building and mat making, and rice is often cooked and kept in the internodes for carrying on a journey.

Melocanna bambusoides.—The real home of this bamboo is in the Chittagong Hill tracts, where it is gregarious and covers large areas. Its cutting and extraction is easy and cheap, as the culms are single and not in clumps. It is excellent for building, basket work and thatching, and many millions of culms are exported annually from Chittagong, most of them finding their way to other Indian ports. The fruit, which is large, with a fleshy pericarp, is sometimes eaten.

Ochlandra travancorica.—The *eetta* or *eta* bamboo of the mountains of South India in Travancore and Tinnevelly. It is an erect, reed-like, gregarious bamboo which covers considerable areas of country. An attempt was made, and a company was actually floated, to utilize the culms of this bamboo for match splints and boxes. A thin veneer was scooped from the inner side of the bamboo to be made into boxes, while the portion left was used for the splints. The straight fibre and strength of the bamboos lent themselves to this industry, but the undertaking had to be abandoned owing to the difficulty of getting

machinery which would cut veneers from culms of varying diameters. This bamboo is likely to prove valuable as a source of pulp for paper-making, experiments having shown that it produces the best fibre of all the Indian bamboos so far tested for that purpose.

Pseudostachyum polymorphum.—A thin-walled, shrubby bamboo of river-banks and valleys in the Terai and lower hills of Sikkim, and extending eastwards to Assam, the Garo Hills, and Upper Burma. It is in considerable demand among tea-planters and others, as giving the best materials for basket and other estate work. It is also used in betel-leaf cultivation and for making umbrella handles and walking sticks.

The utilization of bamboos for paper-making is dealt with separately in Chapter XXII.

Canes

Canes or rattans are the stems of climbing palms belonging to several genera of the *Palmaceae*. Of these, *Calamus* constitutes the most important group, and few forest plants are of greater value to the inhabitants of moist tropical regions than these canes and rattans.

They owe their chief value to their great pliability, strength, and length. As substitutes for ropes, they are invaluable, and in the districts where they abound, canes 300 to 400 ft. in length are frequently employed as the bearing ropes of suspension-bridges. They are used in all kinds of forest work, such as towing logs of timber and tying up rafts, and are unsurpassed for basket-work. Canes are also much sought after for walking sticks and umbrella handles, and cane furniture always provides a big market. They are exported to Europe in fairly large quantities for basket-making and wicker-work. The strips from the outside, with the smooth outer surface, are used for such work as caning chairs and settees, while lustreless strips from the inside of the cane serve for making furniture, perambulators, baskets, sieves, mats, ropes, coverings for demijohns and various other articles.

The more important canes of India include the following:—

Calamus acanthospathus.—A common and extensive climber of north-east India. In the cane forests of Bengal it is getting scarce, due to heavy working, especially in the neighbourhood of tea gardens, where it is extensively used for making tea baskets. It is also used for cane bridges, chair making, and walking sticks.

Calamus guruba.—A slender cane which is still fairly common in Burma and north-east India.

Calamus latifolius.—By far the strongest cane which finds its way on to the Indian market. It is plentiful in Burma, East Bengal, and Assam, and

may be regarded as the true rattan or East India cane, so much favoured for walking sticks.

Calamus tenuis.—A very long climbing cane found all along the sub-Himalayan tracts from Dehra Dun to Assam, and also in Burma. It is the common cane of North India and is used for basket-work, mats, screens, and furniture.

Calamus viminalis.—A thin strong cane which makes excellent walking sticks. It is the chief rattan of Burma, spreading over into China and the Malay Peninsula.

Calamus rotang.—A slender cane which may be regarded as the common rattan of Central and Southern India. It is used for basket-work, chairs, mats, blinds, etc., but it is not very strong though easily worked.

There are several other canes of more or less local importance, the Andaman Islands being especially rich in *Calamus* species, but those mentioned above are the most common and are typical of the genus.

XIII

DISTILLATION AND EXTRACTION PRODUCTS

Grass Oils; rosha grass oil—lemon grass oil—citronella oil—vetiver oil. **Wood Oils**; sandal wood oil—agar oil—deodar oil. **Leaf Oils**; camphor—eucalyptus oil—cinnamon oil—wintergreen oil. **Miscellaneous Distillation and Extraction Products**; cutch and *katha*—mohwa liquor—the destructive distillation of wood—chir tar—deodar tar oil.

Grass Oils

There are in India five well-known commercially recognized aromatic oils which are distilled from forest grasses. These are rosha grass oil, which is also known as palmarosa or geranium oil, lemon grass oil, citronella oil, ginger grass oil, and vetiver oil.

Rosha grass oil

Rosha grass or palmarosa oil is the product of **Cymbopogon martinii,** which occurs in the Central Provinces, United Provinces, Berar, Bombay, and Hyderabad. Its occurrence is generally local, but where present it forms a dense undergrowth. Two important varieties are to be found, a sporadic variety bearing the vernacular name of *motia* and a gregarious variety of less value known as *sofia*.

Although these two varieties can be recognized in the field by their general appearance and by their distinctive smell, it has not proved possible to differentiate them botanically. Environment exercises a powerful influence on the oil-producing qualities of this grass. It will yield the oil for which it is noted in one region and, if tried elsewhere, it may not do so, or only to a very small extent. It is only the *motia* variety which is used for the production of rosha grass oil, the *sofia* variety being said to produce ginger grass oil.

The distillation of the oil is generally carried out by contractors leasing the grass areas, or by villagers who are experts in this work although using the crudest of apparatus.

The portion of the plant from which the oil is obtained is the inflorescence and leaf, while only small quantities of the oil can be obtained from the stem itself. The inflorescences and upper third of the stem are collected in September and October, and are tied into bundles, or *pulas*, of about ¼ lb. each. The

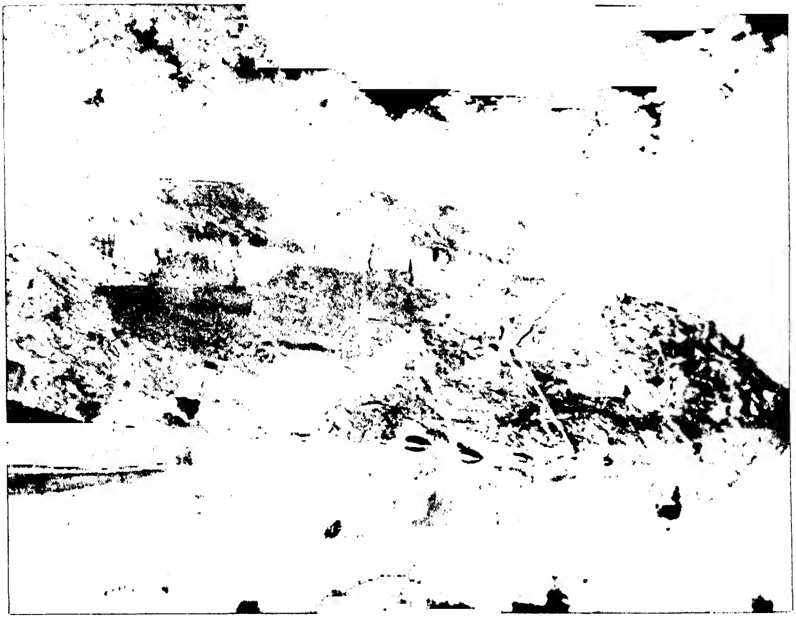
grass is either distilled in a partially green state or the *pulas* are carefully dried in the shade before distillation, during which period they lose from about 20 to 40 per cent of their weight according to the degree of dryness which they are allowed to attain before being used.

Distillation is carried out as follows:—

The still is in all cases erected within a few feet of a stream or pond, not only because considerable quantities of water are required for the distillation process, but also for cooling the condenser. The still itself is of copper or iron and of cylindrical shape, with a sufficiently large opening at the top to allow of the charge of grass being introduced. The still is either built in and covered with mud up to the neck, or is simply supported on stones over a fireplace. The opening at the top of the still is closed with an iron or wooden disc with a hole drilled in the centre, the disc being luted to the still with flour paste or mud, with the help of a rag which forms a wrapper over the joint. In the hole in the centre is fitted a short bamboo, the joint of which is also made good with flour paste. To this, at an angle of about 60°, is tightly bound another bamboo tube about 6 ft. in length and 1½ to 2 inches in diameter, the tube being formed by drilling the nodes through with a hot iron before it is fixed to the still. This tube slopes down into the condenser, a copper vessel with a long narrow neck, into which it is fixed with a cloth stopper. The condenser is placed in a pool or stream of water, the upper part of the neck projecting above the water. The boiler is tightly packed with the flower stems of the grass, and water is added in the proportion of about 45 gallons of water to 100 lb. of grass. A fire is then lit below it and the steam passes over into the condenser where it condenses into water and oil. Distillation is complete at the end of about 3 hours, and the bamboo pipe is then disconnected at the still head and the oil collected from the condenser. This is either done by filling the condenser with water and skimming off the oil or by transferring the whole distillate to a circular iron tub where it is made to revolve with the help of a large spoon, the oil which collects in the vortex being taken off with the help of a ladle and transferred to a container, which is usually a kerosene tin or iron drum. The yield varies according to the proportion of stem and leaf to flower, but a yield of 1 per cent by weight can be considered very satisfactory.

This method of distillation is extremely crude, and the outturn of oil is not very high as only the top layers of the grass come in actual contact with the steam. These stills have, however, been somewhat improved by fitting them with a perforated false bottom on which the grass is packed, thereby allowing most of the grass to come in contact with the steam.

The modern method of distillation is a distinct advance over the old method described above, in that steam can be introduced at the bottom of the still so



'Country' method

Modern method

PLATE XI. Distillation of rosha grass oil

Facing p. 244.

that it passes right through the packed grass from the bottom to the top, and a very much higher percentage of oil is extracted in this manner. The yield in this case is about 1·26 per cent on the weight of grass.

The new apparatus consists of a boiler for producing steam, a copper still in which the grass is packed and through which the steam passes taking the oil with it, a condenser filled with cold water, and a separator in which the condensed mixture of oil and water is collected and the oil separated.

As the result of experiments carried out by the Forest Research Institute with this new apparatus, two companies were formed to distil rosha grass oil by this method, one operating in the forests of the Bombay Presidency and the other in those of the Central Provinces. Difficulties were, however, experienced in keeping the stills working in out-of-the-way places in malarious jungles, and just about this time also there was an appreciable drop in the price obtained for this oil. Both the companies went into liquidation after working only for a couple of years.

Rosha oil is consumed all over India, where it is used for the manufacture of attars. Its chief use is for the adulteration of attar of roses, either by dilution of the attar or by sprinkling the rose leaves with rosha oil before distillation takes place. It is claimed that rose attar, which is liable to crystallize at cold temperatures, does not do so if adulterated with rosha oil. Rosha oil found on the market in India is rarely absolutely pure and is nearly always adulterated with turpentine, linseed, groundnut oils, etc., the adulteration often being carried out by the distillers themselves.

Large quantities of rosha grass oil are said to find their way to ports on the Red Sea and Egypt, where it is used as a perfume, while the demand for it in Istambul is said to be as an adulterant of attar of roses.

In Europe and America it is used for extraction of geraniol, of which the pure oil contains as much as 90 per cent. This is used in perfumery where a cheap geranium odour is required. The price obtained for rosha oil has declined since 1920, partly as a result of a return to more normal conditions after the Great War, and partly as a result of increased production of the true geranium (*Pelargonium*) oil in the French colonies of Réunion and Algeria. The result of this greatly increased production of geranium oil has been to lower its value. The price of rosha oil must necessarily adapt itself to that of the true geranium oil and its price has, therefore, dropped in sympathy. A further depressing cause is, perhaps, to be found in the fact that cheap synthetic products having a geranium odour are now available. The result of the drop in price has been a decrease in the production of the oil in India, and this has naturally had a depressing effect on the price obtained for the leases of rosha grass areas.

Lemon grass oil

Considerable confusion exists, from a botanical point of view, between the various grasses from which lemon grass oil is distilled, but according to Dr Stapf the oil is produced from the following species: **Cymbopogon citratus, C. flexuosus, C. pendulus,** and **C. coloratus.** A sample of grass received from Cochin State, said to be used for the production of lemon grass oil, was identified as *Cymbopogon nardus*, var. *confertiflorus.*

The above species occur chiefly in South India, in Travancore, Malabar, and Cochin, and are cultivated in the northernmost parts of Travancore and in small sections of Cochin State.

The distillation of lemon grass is an old-established industry, dating back many hundreds of years. The whole of the grass is used for the production of the oil, and it is therefore cut a few inches above the root stock. Distillation is carried out in much the same manner as that of rosha grass oil, but in this case a copper boiler is used and the steam is condensed by being passed through a coiled pipe, which is immersed in cold water kept cool by the frequent addition of fresh cold water. The coiled pipe eventually leads out into a tin vessel, in which the condensed mixture of water and oil is allowed to settle. The oil is then scooped off, and again gently heated to get rid of any surplus water. The oil produced is generally rather dirty and contains considerable resinous matter but is not adulterated. Distillation is said to be carried out throughout the year except from February to April. Production and exportation go on simultaneously, and more or less continuously, and appear to be largely controlled by prices which are affected more by the requirements of Europe and America than by variations in the output.

Lemon grass oil has a strong scent of lemons, and is often called citronella or Indian verbena, although it is not the true oil of citronella. It is in great demand in Europe and America for the citral which it contains. This is used in the manufacture of artificial perfumes and also for scenting soaps. Lemon grass oil is used extensively in India for cooking and flavouring. Its medicinal properties are doubtful, but it is popular as an anti-mosquito agent when rubbed on the face and hands.

The main supply of lemon grass oil is produced in India, though some is now exported from Burma, Ceylon, Java, and Uganda.

Citronella oil

True oil of citronella is obtained from various varieties of *Cymbopogon nardus* and from *Cymbopogon winterianus*, Ceylon plants, some of which are now cultivated in Java. The commonly cultivated variety is known in Ceylon as *lena-batu* (**Cymbopogon nardus, var. confertiflorus**). Preference is given to

this variety, as it is hardy and does not require frequent replanting or careful attention and gives a good yield. The grass is grown by planting shoots at regular distances one or two feet apart. The grass can be cut eight months after planting and is cut every third month subsequently. After cutting, the grass is exposed to the sun for a day to wither, and is then carted to the factory for distillation, care being taken not to keep it in heaps as this causes fermentation. The old-fashioned earthen stills are now rarely met with, and distillation is carried out in up-to-date stills, two such stills generally being worked side by side as this greatly expedites the work. Distillation is usually completed in 6 hours and two distillations are made in a day. The oil and steam pass into the condenser through a filter and ultimately enter a cylinder. The oil floats on the top of the water, which is drawn off from below, and is then skimmed off with a cup. Before it is shipped it is subjected to several filterings.

When cultivated, an acre is said to yield about 4,500 lb. of grass per crop (quarterly) or about 18,000 lb. per annum. Good grass will yield about 17 lb. of oil per crop or about 68 lb. per year per acre.

Citronella oil is used for scenting soaps and is exported in large quantities to Europe and America from Ceylon and Java.

Vetiver oil

This oil is obtained by distillation from the roots of **Vetiveria zizanioides**, the khus-khus grass. This grass is found growing on moist or heavy soils, especially along the margins of lakes and streams in the plains and lower hills of India and Burma. The roots when distilled with steam yield a fragrant oil known in European trade as vetiver oil, a higher outturn of oil being obtained from material collected when the grass is in full bloom. This oil commands a high price in Europe, where it is employed in many favourite scents and in perfuming soaps. It is the most viscid of essential oils and its sparing volatility is taken advantage of in fixing other perfumes.

Distillation of the oil is slow and difficult owing to its viscosity and high boiling point. European supplies of the oil are usually made in Europe from roots imported from India, Java and elsewhere. It is, however, distilled to a small extent in India and more extensively in Réunion (N. Africa).

The quality of the oil depends largely on the locality in which the roots are grown, the best material being said to come from Travancore and Tuticorin.

In India it is used as a perfume and for flavouring sherbet.

Wood Oils

Oils distilled from the woods of Indian trees are not numerous. There are only two of any real importance, namely sandal wood (**Santalum album**) oil and

agar wood (**Aquilaria agallocha**) oil. The former is one of the most important forest products which India possesses.

Sandal wood is extremely valuable and a very large revenue is obtained by its sale in Madras and Coorg. Conditions differ somewhat in Mysore, which is the largest sandal-wood producing area, in that the oil is distilled from the wood in factories at Mysore and Bangalore and is then offered for sale. The revenue derived from the sale of this oil is very large.

Agar wood is not so important from a revenue-producing point of view, as only a small proportion of the trees produce this wood, and the trees themselves are not very numerous. It is, nevertheless, an interesting product and the essential oil which is extracted from it is very valuable.

Sandal wood oil

From a commercial point of view, the most important and best-known of the Indian wood oils is sandal wood oil, obtained from **Santalum album.**

This small evergreen tree, which is a root parasite on a long series of host plants, frequents open forest lands with grass and patches of other trees, and is usually found growing on red and stony soils. The tree grows well on rich soil, but the wood is then deficient in odour, and consequently inferior commercially girth for girth.

The chief sandal-producing areas are in Mysore, and in parts of Madras, Coorg, and Bombay. In Mysore and Coorg, sandal is a 'royal tree' and a monopoly of the State, but in other parts where it occurs private ownership is authorized, though stringent rules are in force to regulate its removal.

The exports of sandal wood vary from year to year. In 1938, over 1,000 tons were exported, whereas in 1939 the export dropped to 900 tons. About 80 per cent of the wood usually goes to America. Sandal wood oil is also exported in large quantities, as much as 18,000 gallons being sent out of the country in some years, though the export of oil also has fallen in recent years.

Sandal wood is extremely valuable, and careful provision has to be made to prevent theft during the course of its extraction from reserved forests, even the sawdust being collected and sold. A short account of the general procedure of extraction adopted in Madras is given below, and is instructive as showing the extent to which protection from thefts and fraud is given.

Most of the sandal-producing areas in Madras are covered by rough working plans, the principle of which is to work the whole sandal-producing area on a cycle of 6 years. In each coupe, it is usual to remove all dead and dying trees (i.e. those that will not live for another 6 years) and all trees above 32 inches in girth at 4′ 6″ height, at which stage a tree is considered to be mature. The root stumps are also removed.

Before any extraction is attempted, the whole coupe is gone over, and every tree to be extracted is marked with a band of tar at breast height and serially numbered. The girth at breast height, the height of the tree up to the heartwood limit, and its location are, at the same time, recorded in a special register. This marking is then checked by the Range Officer, and an estimate is prepared of the probable heartwood that will be obtained.

The selected trees are then extracted in strict rotation, each tree being uprooted by digging round it deep enough to secure all side roots and rootlets containing heartwood. No root containing heartwood 'greater than the size of half a rupee' is allowed to remain in the ground. On the fall of a tree its top and small branches containing no heartwood are lopped off. All the main branches are sawn off the trunk at the point of their insertion, so that the latter is clean and free from basal ends of branches. Each branch is marked with the number of the tree from which it has been obtained and is also given a number of its own, to facilitate the reconstruction of the tree as will be described later.

The main root is sawn off, together with the side branches, and each is carefully numbered with the number of the tree and its own serial number.

The sapwood is valueless, as it contains no oil, and it is customary, therefore, to rough-clean the trees in the forest before dispatch to the final cleaning depot. This is done by chipping off the sapwood with axes, adzes, or bill hooks, so that only a mere layer of sapwood, about $\frac{1}{8}$th inch thick, is left over the heartwood. On no account must any heartwood be removed during this operation. The main stem, branches, roots and side roots are all treated in the same manner.

The dressed stems and branches which are too heavy to be carried whole are sawn into billets of convenient length, and each billet is numbered on the cross-section with the tree number and its own billet number. Great care and discretion have to be exercised in billeting as the value of any billet is considerably enhanced by its freedom from knots, bends, etc.

As soon as a tree has been felled and dressed, as described above, all the pieces into which it has been cut are hammer-marked at both ends, numbered on the broad ends, and the length and mid-girth of each billet and root are recorded in a special form. In this form the total weight of the trunk and branches is also recorded. A copy of this form accompanies every consignment of wood dispatched from the forest to the final cleaning depot.

On arrival at the final cleaning depot, the measurements of each billet and root are checked, and the whole tree is reconstructed to see that all the wood has been received correctly. In this manner any theft of no matter how small a portion can be immediately detected. The trunk and root wood are again carefully weighed and recorded.

The wood, which has been rough-dressed as described above, is not, however, yet fit for the market. All traces of sapwood are, therefore, removed with adzes and spoke shaves, care being taken that as little of the heartwood as possible is removed during the process. This final cleaning must be very thorough, and the billets and roots must be left with a clean, smooth surface. The value of the wood is reduced by bad cleaning and hence great attention is paid to this operation.

After final cleaning, the billet wood and root wood of each tree are weighed separately and entered in a special form. Each billet and root is marked with the tree number and its own individual number, which are stamped on the ends with metal punches. It is thus possible to reconstruct any tree even after final cleaning.

The sandal wood produced in Coorg and Madras is sold by weight in public auction at definite sale depots. and all wood received at these depots is carefully classified prior to sale, billet wood and root wood being classified separately. A limited quantity is also sold retail for domestic purposes.

Sandal wood is used for fancy carved boxes, picture-frames, and other articles, also for combs, and coffins for the rich in China, and is burned as an incense by Parsis, Arabs, and Chinese, and at Hindu funerals; the wood rubbed down in water is used for Hindu caste marks, and as an external application for headaches and certain skin diseases. Sandal wood oil is distilled from the heartwood.

In Mysore, a certain amount of wood is sold to the public retail, but the greater part of the supply is used by the Mysore Government for distillation of the oil in the up-to-date factories at Mysore and Bangalore. The oil so produced is sold under a guarantee of purity, and the Mysore Government has its own agents for the sale of this oil in London and in America.

Much of the sandal wood from Coorg and Madras finds its way to Europe and America, where it is distilled for the oil which it contains. Distillation of the oil is also carried out locally in parts of Madras in a small way, but the extraction of the oil is mostly done outside the sandal-producing areas, chiefly in Oudh.

The distillation procedure varies in different localities but the principle is the same. In local distillation, small chips or shavings of the heartwood or rootwood are placed in a large earthen pot, and water added in the proportion of about 6 gallons to 56 lb. of chips. A lid is fixed to this pot, and from it a copper tube, about 1¾ inches in diameter and 5 ft. in length, leads into a copper condenser which is suspended in a trough of cold water. A fire is then lit under the boiler, and steam mixed with oil passes over in the usual way into the copper pot in which it is condensed. It is then allowed to cool and the oil is found floating on the surface of the water and skimmed off. The boiling often takes

PLATE XII. Trimming sandal wood for sale in Bombay province

Facing p. 250.

up to 3 or even 4 weeks, the fire burning day and night, so that a dozen or more stills are usually placed side by side with the whole series supported on a mud and brick frame. The oil coming over first is the best in quality, and the yield is about 2 seers of oil to one maund of chips used.

Sandal wood oil finds its chief uses in perfumery and medicine and is extensively used in soap-making. Its value in perfumery and soap-making lies in its fixative powers.

Mention must be made of the disease known as spike, which has become increasingly prevalent in many of the sandal-wood producing areas. This disease is doing enormous damage, as the trees affected eventually die. It is now the opinion that this disease is produced by a virus, but it is not known definitely as yet how the infection spreads. The matter has become so serious that the Governments of Mysore, Madras, and Coorg are all co-operating in an investigation which is being carried out by the Indian Institute of Science, Bangalore, assisted by local officers and the Forest Research Institute, Dehra Dun.

Of recent years, a substitute for true sandal wood has been coming on to the market in large quantities from Australia. It is known commercially as Australian sandalwood and is from a small tree identified as **Eucaria spicata syn. Fusanus spicatus**. Commercial West Australian sandalwood oil is also finding its way in increasing quantities into not only the markets of Europe and America, but India as well, and is affecting the sales of true sandal wood oil. The oil is really a mixture of oils, and though passing the minimum standard of santalol content required by the *British Pharmacopœia* (1933) does not possess all the qualities of true sandal wood oil.

Agar oil

Another interesting wood oil is agar attar or agar oil, distilled from dark brown resinous portions of the wood of **Aquilaria agallocha**. This tree occurs only on the east side of India, in Assam, Bhutan, the Khasia Hills, and parts of Bengal and Burma. Little is known regarding the occurrence of the brown patches of wood which appear in some trees but not in others, especially in and round old wounds and hollows. That the resinous infiltration found in these is due to a fungus attack in some form is certain, and it has now proved possible to impregnate other trees by driving into them pegs from trees already containing agar wood.

Agar wood itself, also known as eagle wood, is in great demand in China, where it is used for burning as incense and in the manufacture of joss-sticks, and there is quite an important export to that country. The oil is obtained in the usual manner by distilling with water chips of what is known as *dhum* agar, which is soft and yellow to almost white in colour, as compared with real agar

wood which is hard and brown. The distilled oil is a valuable perfume retainer and is much prized by European perfumers for mixing with their best grade scents.

Deodar oil

By steam distillation of the chips or sawdust of **Cedrus deodara**, an oil known as deodar oil is obtained. This is a reddish-brown coloured oil possessing a characteristic balsamic odour. The oil has been examined by the Imperial Institute, London, and samples were sent in 1915 to English and continental firms of soapmakers and essential oil distillers, who expressed the general opinion that a market could probably be found for the oil if it was offered at a low price. One firm stated that the oil might find a small market as a substitute for cedar-wood oil, derived from *Juniperus virginiana*, but that its value would only be 2s. 6*d*. per lb. At this price it was not considered that the production would be remunerative, and no further steps have been taken to put this oil on the market, though there would be ample raw material from the wastewood resulting from the conversion of deodar sleepers. This oil must not be confused with deodar tar oil which is obtained by destructive distillation of the wood of *Cedrus deodara*, an account of which will be found on page 264.

Leaf Oils

Camphor

Among distillation products obtained from leaves may be mentioned the oil and crystals obtained from **Cinnamomum camphora**, the true camphor tree. This tree is a native of Japan, Formosa, and parts of China. It has however been successfully introduced into India, Burma, and Ceylon, but only on a small scale.

Most of the camphor of commerce was at one time prepared by the distillation of the wood of mature trees, a wasteful procedure as the trees took many years to mature and were then ruthlessly cut down. Later, it was discovered that it was more profitable to distil oil from the leaves rather than from the wood of the tree. This fact led to the growing of camphor on the tea-bush system and the periodical picking or clipping of the leaves while leaving the bushes intact. The oil is extracted from the leaves by steam distillation. By this process both solid camphor (crystals) and camphor oil are obtained, but the latter is not so valuable as oil derived from the distillation of the wood, as it does not contain safrole, which is an important article of commerce used in perfumery.

Both the crystals and the oil of camphor are used extensively in medicine for the treatment of colds and fevers. It is a good antiseptic and the oil is used

for rubbing on the body to relieve stiffness. By far the greatest impetus that the camphor market ever received was, however, the discovery and manufacture of celluloid, and this has been further augmented by the increased demand for the production of films for the cinematograph industry during the last two decades.

Japan has by far the largest share of the camphor trade, but the market is now controlled by the production of synthetic camphor which is derived chiefly from turpentine. If the price of natural camphor rises unduly, synthetic camphor at once comes in to compete with it, thereby preventing the demand of high prices for the natural product.

Eucalyptus oil

Eucalyptus oil is obtained in India by distillation of the leaves of **Eucalyptus globulus** (the blue gum tree), and this industry is now being conducted on a fairly extensive scale in the Nilgiri hills of South India. Many other *Eucalyptus* species give oils of a similar nature, but *Eucalyptus globulus* is the only oil-producing species which has been introduced into India on a large scale.

The leaves for distillation are obtained from Government plantations as well as from private forests, and are collected from trees felled in the coupe for supplying fuel to Ootacamund and other towns in the Nilgiris. Mature leaves of 15-year-old trees and upwards are preferred, and they are dried in the shade for 3 days prior to use. The leaves are tightly packed between perforated plates in a still and are then distilled for 8 hours, the water being kept at a constant level by an inlet cock. The crude oil, which is collected in a condenser, is filtered through filter papers, and is then refined by being mixed with water and a small quantity of caustic potash, and is redistilled in a small still. The refined oil thus obtained is again passed through filter papers before it is put on the market.

The capacity of a main still is about 800 lb. of leaves, and these, when distilled with about 36 gallons of water, give about 120 oz. of oil, which is reduced to 96 oz. on redistillation.

Eucalyptus oil is used for medicinal purposes, for perfumery, and for scenting soaps. It is especially effective in colds and other catarrhal complaints.

Cinnamon oil

There are two kinds of cinnamon oil known in commerce, namely bark oil and leaf oil. The former, which is not usually prepared in India, is obtained by distilling chips of the bark of **Cinnamomum zeylanicum**, the true cinnamon tree of South and West India, Burma and Ceylon. The bark oil is prepared in Ceylon, but the greater amount exported is not genuine bark oil, as leaves of

this species are often added to the bark during distillation, or cinnamon leaf oil is added to the bark oil after distillation.

Leaf oil is distilled from the leaves of *Cinnamomum zeylanicum* in the Malabar and Kanara Districts of Madras.

A typical still consists of a hearth with five openings on which are placed five large earthen pots about 2 feet deep and 2 feet broad at the broadest point. Over the mouth of each is placed a smaller earthen pot mouth downwards. The mouths of the two pots are of the same size and the joint is made air-tight by plastering on mud. In the centre of the inverted pot is a hole, allowing a knee-shaped bamboo pipe to be fitted and the joint made good with clay. The bamboo pipe is some 5 feet in length, and runs, at its lower end, over a pot filled with water; in the water is placed a second pot covered and half filled with water, into which the distilled oil trickles.

Distillation is carried out in the following manner:—

The large pots are filled in the early morning with about 8 inches of water, over which the green leaves are tightly packed. The smaller pot is then adjusted and sealed down with clay, the pipe is put into position, and distillation begins. Distillation is carried on for about 16 hours with the same charge of leaves, the temperature of the water never being raised quite to boiling point. The steam passes over and condenses partly in the pipe and partly in the inner condensing vessel. A wet rag is kept over the mouth of the condensing vessel to keep in the steam and vapour of the essential oil and to assist condensation. Water is kept in the condensing vessel and the oil, being heavier than water, sinks and the water lying over it prevents it from evaporating. The water in the outer vessel is changed once during the day. The outturn of oil is about 0·75 per cent by weight.

The oil is of a brown colour, with a slight camphor-like smell resembling that of cloves. It is used in medicine and as an embrocation in cases of rheumatism and for flavouring sweets and confectionery. It is also exported to the Persian Gulf and Arabia, where it is said to be mixed in small quantities with curry by the Arabs.

Wintergreen oil

Another interesting product under this section is wintergreen oil, obtained from the leaves of **Gaultheria fragrantissima**. The shrub is common in East India and in the Nilgiri hills, where it is gregarious on dry hillsides and noticeable for its bright turquoise-blue berries, which are eaten by certain tribes. The chief sources of supply are however in America, and although Indian wintergreen oil is as good as the American product the industry has never developed itself in India on any large scale. Wintergreen oil is of interest as producing

salicylic acid, from which the well-known aspirin can be prepared, but nowadays most aspirin preparations are made synthetically. Carbolic acid can also be made from it. The oil itself is an excellent antiseptic and is largely used for rubbing on the body in cases of rheumatism and similar ailments.

Amongst other leaf oils may be mentioned the *ngai* or blumea camphor prepared from **Blumea balsamifera**, an evergreen shrub of the Eastern Himalayas and Burma, and cajuput oil obtained from the leaves of **Melaleuca leucadendron**. This valuable green-coloured oil is used as an application to relieve rheumatism, as a sudorific, and for gastric flatulence. The tree occurs sparsely in Burma, and is not found in India. It is common in the Malay Peninsula.

Miscellaneous Distillation and Extraction Products

The three previous sections have dealt with the oils obtained from grasses, woods, and leaves by *steam distillation.* In this section an account will be given of the products obtained from wood by *extraction* with water and by the *destructive distillation of wood.* There are not many of the former, but the group includes cutch and *katha,* two forest products of great economic importance to India. Destructive distillation differs essentially from steam distillation in that no steam is used, the wood itself being heated in a closed retort out of contact with the air.

Cutch and katha

Cutch and *katha* are obtained from the heartwood of **Acacia catechu**, a common tree found in most deciduous forests of India and Burma, mainly in riverain tracts. A third article of commerce is also obtained from this tree, in the shape of a white powder which appears as a deposit in the wood, and is known as *kheersal.* In Madras, cutch is prepared from the heartwood of **Acacia sundra**, which replaces *Acacia catechu* in South India. In European commerce the term 'cutch' also includes the extract of mangrove barks.

Cutch.—The preparation of cutch is carried out in different ways in different localities, though the main essentials are the same. The process is essentially one of *extraction* rather than distillation, in that the chips of wood are boiled up in water and are not treated with steam. The most generally used 'country' procedure for making cutch in the forest is roughly as follows:—

The heartwood, preferably that showing white specks of *kheersal,* is cut into chips which are boiled with water in earthen pots for about 12 hours. The time for which the chips are boiled depends upon their size; the smaller the chips the less the time for which they need to be boiled and the greater the outturn of *cutch.* Sometimes the liquid is poured into other pots in which liquid

of a thicker consistency is boiling, and this process is continued until the liquid is of the correct consistency. Finally it is poured into an iron cauldron and further boiled and stirred, until it attains the consistency of syrup, when it is poured out into wooden frames lined with leaves and allowed to cool. It then hardens into a dark brown, solid, brick-like mass, in which form it is marketed.

The outturn of cutch obtained from a given quantity of heartwood depends upon the quality of the heartwood and the efficiency of the extraction. Experiments in Burma showed that 1 ton of heartwood yielded from 200 to 300 lb. of cutch.

Cutch is an important commercial product, largely exported and used as a dyeing and preserving agent. It is extensively employed for dyeing canvas for boat sails a reddish-brown colour, and for dyeing and preserving fishing nets and ropes. Fishing nets treated with cutch are not affected by salt water. It is also used in medicine as an astringent, but is not satisfactory as a tanning agent.

Katha.—*Katha* is prepared in the first stages in the same way as cutch, but the reboiled liquid is poured into moulds dug in fine sand which absorbs the tannic acid and leaves a residue of catechin to crystallize out into the *katha* of commerce. *Katha* is, therefore, similar to cutch but with most of the tannic acid extracted. It is used extensively throughout India for eating with *pan*. It is not exported, but the Indian demand for this commodity is enormous. It is very astringent and is said to help digestion.

The rough 'country' methods of manufacturing both cutch and *katha* as described above are wasteful, because when making cutch it is not possible to recover the catechin or *katha*, while in the manufacture of *katha*, the catechu-tannic acid (cutch) is allowed to go to waste in the sand in which the *katha* is collected. As the result of experiments at the Forest Research Institute it has been found possible to prepare cutch and *katha* at one and the same time, by a slight modification of the 'country' methods at present in force in most parts of the country. The procedure adopted is as follows:—

The heartwood is chipped with axes in the ordinary manner and the chips are then placed in a vessel in which they are boiled with water over an open fire; the time for which they are boiled depending on their size. This operation is best carried out in a tinned copper vessel. On no account should iron vessels be used, as the catechu-tannic acid (cutch) forms a greenish-brown compound with ferric salts, which impairs the colour of the cutch and *katha*.

After boiling, the liquid is poured into another vessel in which the concentration is to be carried out, and into which it is strained through a piece of muslin to remove all traces of chips, sand, and other impurities. The liquid must be strained *while still hot*, or there is danger of the catechin (*katha*)

crystallizing out on the cloth and so being lost. In the meantime fresh water is added to the chips, which are again boiled. In some cases as many as 5 boilings are made, but three should prove sufficient if the chips are small.

The liquid obtained by straining is now concentrated over a fire till the required density is obtained. Experiments have shown that at Dehra Dun in the cold weather it is best to concentrate the liquid till it attains a density of 1·07 to 1·08, but in other parts of the country where it is warmer it may prove better to concentrate the liquid still further. The optimum concentration can be ascertained by experiment, but in no case should the liquid be concentrated to a high degree as the catechu-tannic acid retards the crystallization of the catechin in thick solutions. The density of the liquid is easily ascertained by means of a hydrometer.

As soon as the desired concentration has been attained, the liquid should be set aside to cool slowly and to stand for several days. In cases where the temperature is high it would be advisable to reduce the temperature of the solution further, after it has reached atmospheric temperature. This can be done by immersing the vessel containing the liquid in cold water. As soon as the liquid has cooled sufficiently, it should be 'seeded' with some crystals of catechin (*katha*), as this accelerates the formation of *katha*.

Catechin is soluble in hot water but very sparingly so in cold, while catechu-tannic acid is soluble in both hot and cold water. This fact is taken advantage of to separate the catechin from the catechu-tannic acid, and hence the necessity for allowing the liquid to become quite cold so that the catechin can crystallize out.

After the liquid has been allowed to stand for some days, it will be found that on the bottom of the vessel there is a mass of crystals of catechin (*katha*).

It is now necessary to separate these crystals from the mother liquid, which consists of catechu-tannic acid and a small amount of catechin which has not crystallized out. This is best done by straining the liquor through fine muslin, when the catechu-tannic acid will pass through and leave the catechin on the muslin. It will probably be found that, when the liquor is first poured onto the muslin, some catechin crystals will pass through the filtering material, but, as a bed of crystals forms on the muslin, this will cease and only catechu-tannic acid will pass through leaving the catechin on the cloth. The cloth should be disturbed as little as possible while filtration is in progress so that the bed which forms is not broken.

The catechin adhering to the cloth after filtration may then be washed with some *pure cold water* to remove all traces of catechu-tannic acid. It should be scraped from the cloth and dried between sheets of cotton covered top and bottom with sand. As soon as it has partially dried it can be cut into cubes or

other suitable sizes for the market, and further dried and stored in racks with a free circulation of air till ready to be packed for dispatch.

The mother liquor (catechu-tannic acid or cutch) can be again concentrated after the extraction of catechin, till it attains a specific gravity of about 1·1, when it is allowed to cool again and deposit a further crop of catechin, which can be removed as before. The final mother liquor thus obtained will be practically devoid of catechin and can then be concentrated and made into cutch in the ordinary way.

The amount of catechin which can be obtained from a given quantity of wood depends on the catechin content of the wood and the care taken in preparation. *All unnecessary heat should be avoided* as this tends to oxidize the catechin, forming catechu-tannic acid.

Cutch and *katha* are also being made in an up-to-date factory at Bareilly in the United Provinces. The principles of manufacture are the same, except that all the operations are carried out by machinery. The quality of the cutch and *katha* now made by these scientific methods show a great improvement over those obtained by the old 'country' methods, and it is probable that they will gradually oust the old 'country' methods altogether, especially as the demand for *katha* is steadily on the increase. This has naturally led to an increase in the demand for *khair* trees and the price has risen accordingly. The Bareilly factory alone has a contract for the supply of 10,000 trees of over 3½ feet girth per annum from the United Provinces, and the demand for trees for 'country' manufacture is greater still.

Mohwa liquor

Mohwa liquor is obtained from the flower corollas of **Bassia latifolia**, a common tree in most parts of India. The collection of flowers is usually allowed free to privilege- and right-holders, who sell them to Government distilleries. To facilitate collection, the collectors often burn the ground under the trees, and forest fires are not infrequently started in this way. The flowers, fresh or dry, form an important article of diet of many forest tribes and villagers living in the vicinity of forests, and for this reason it is usual to leave *mohwa* trees standing in coupes marked for felling, especially in the Central Provinces.

Mohwa liquor is obtained by allowing the flowers to ferment under water and distilling the resulting liquid. It is an intoxicating beverage which might well be termed the whisky of India.

It has been suggested that this liquor might be used for mixing with petrol to form a fuel for internal combustion engines. Experiments have shown that the yield of alcohol is very high, being in the region of 90 per cent, but the pure alcohol (96 per cent by volume), when used in an engine designed for petrol,

has a fuel value of only 50 per cent that of petrol. If used in a specially designed engine, the fuel value would be equal to, or even greater than, that of petrol.

The destructive distillation of wood

Destructive distillation of wood consists in heating wood out of contact with air, in a closed retort provided with outlets through which the volatile and liquid products escape. There are two distinct branches of wood distillation; namely hardwood distillation and softwood distillation. By softwoods is meant coniferous woods only, while hardwoods refer to all broad-leaved species. The process of distillation followed with hardwoods and softwoods is different, owing to the fact that the by-products which they yield differ in character. It is proposed to deal here only with the distillation of the former.

In modern practice the carbonizing vessel for hardwoods is generally a cylindrical wrought-iron retort built into brickwork in a horizontal position. This retort is heated by a fire below, but the naked flame is not allowed to impinge directly on the retort, which is heated only by the hot furnace gases, this result being obtained by utilizing iron or brick shields or arches. The batteries of retorts are set up in rows and the outlet pipe of each retort is connected with a worm condenser made of copper and cooled externally by means of running water.

On the application of heat to the retort, the substance of the wood is charred, which results in volatile products being driven off. Those which are condensible are liquefied again in the condenser and are collected in suitable receivers.

This is the general principle of wood distillation, but the process will be made clearer from the account given below of a wood distillation plant at Bhadravati in Mysore State. This plant, probably the largest of its kind in the East, is the only commercial wood distillation plant in India.

The first step is the preparation of the wood to be used for distillation. This is an important matter as the cost of the wood is more than 50 per cent of the cost of manufacture. In this case all wood below 3 inches in diameter is excluded, because it does not give charcoal of sufficient strength for use in the iron works, while wood greater than 6 inches in diameter is quartered. The billets are cut to lengths of about 4′ 4″ to fit the breadth of the cars in which the wood is loaded into the retorts. The woods used are chiefly species of *Terminalia*, *Cassia*, *Calophyllum*, and *Dipterocarpus*.

Wood, when freshly cut, contains a high percentage of moisture and is not fit for distillation in this state. It is, therefore, necessary to reduce its moisture content before it is used, and this can be done in two ways. The wood is either stacked and exposed to the drying influence of the atmosphere or else the moisture in it is reduced by circulating hot gases through it in a specially constructed

chamber. The former method takes anything from 6 to 12 months to reduce the moisture to the required limit. Sometimes a combination of the two methods is followed, and this is the procedure adopted at Bhadravati.

There are 16 retorts at this plant arranged in 8 pairs. Each of the retorts holds 4 car loads of wood weighing from 18 to 20 tons.

As soon as the cars have been loaded into the retort and the retort closed and made air-tight, the fires are lit in the furnaces below and distillation begins.

As the temperature rises, most of the water in the wood is driven off in the form of vapour and the wood gradually begins to decompose and to give off traces of acetic acid. When the temperature of the vapour reaches 200°C., traces of tar appear and the decomposition becomes more rapid, with a corresponding increase in the volume of the vapours given off.

A portion of the vapours evolved during the decomposition of the wood is non-condensible and issues from the condensers as gas. This gas is burnt under the retorts as fuel.

Carbonization of each charge takes about 24 hours, and the cars of glowing charcoal are then pushed into an air-tight cooling chamber where they are allowed to cool for 48 hours. The charcoal is allowed to cool for a further 24 hours in an open shed before being issued for use in the blast furnaces of the iron works.

The average amount of wood carbonized per day is 240 tons, which yields about 60 tons of charcoal and from 25,000 to 30,000 gallons of pyroligneous liquor.

This pyroligneous liquor contains about 3 per cent of tar in suspension and an equal amount in solution, 4 to 5 per cent of acetic acid and about 3 per cent of alcohol, the remaining 85 per cent consisting mostly of water and impurities.

In the still house, the pyroligneous liquor is first pumped into wooden settling tanks where it is allowed to stand for some time. The suspended tar then settles to the bottom and is drawn off. The tar so obtained is termed 'settled tar' and is distilled in the tar plant to give oils and pitch.

The remaining supernatant liquid is then distilled in copper vacuum evaporators to get rid of the tar in solution.

The tar so obtained is known as dissolved tar, and is not so valuable as the settled tar. It is freed from acid and is burnt under the boilers in the plant.

The distillate from the copper evaporators is then neutralized with slaked lime to convert the acetic acid into acetate of lime. The neutralized liquor is then subjected to fractional distillation to drive off the alcohol and leave behind a dilute solution of lime acetate.

This solution is evaporated to dryness to give solid lime acetate. This is known commercially as grey acetate of lime and is 80 per cent pure.

The alcohol obtained as described above is known as crude wood alcohol or crude methanol. It is refined in the alcohol refinery to give commercial pure methanol.

The settled tar, obtained from the settling tanks into which the pyroligneous acid was first pumped, is treated in the tar plant. The tar is heated in steel stills provided with copper condensers. The first fraction contains acid liquor held in solution by the tar, and oils lighter than water. The second fraction is known as heavy oil. The pitch is left behind in the still in a molten condition and is then run into coolers and allowed to cool.

The light oil is used with pitch to make a black paint, while the heavy oil is redistilled and is then supplied to the creosoting plant as wood-preserving oil or creosote oil. Mixed with fuel oil, it was once used for treating sleepers for the Mysore Railway, but its use for this purpose has now been abandoned.

Laboratory experiments have shown that this creosote derived from wood is as toxic, if not more so, than creosote derived from coal. Experience has shown, however, that some of the tar acids are leached out by moisture, and its toxicity is thereby greatly reduced when sleepers treated with it are exposed to moist atmospheric conditions.

A disinfectant known as 'Kerso' is also made in the tar plant. This is made from the oil known as neutral oil obtained during the separation of the crude alcohol from the pyroligneous liquor. This oil is rich in phenols and is separated by distillation and made into a disinfectant.

All the tar plant products are sold in India, while the acetate of lime and the refined alcohol products are exported, mostly to Japan and England respectively.

Acetate of lime is mainly used for the manufacture of acetic acid, which is used in the textile and rubber industries and in the manufacture of cellulose lacquers and artificial silk.

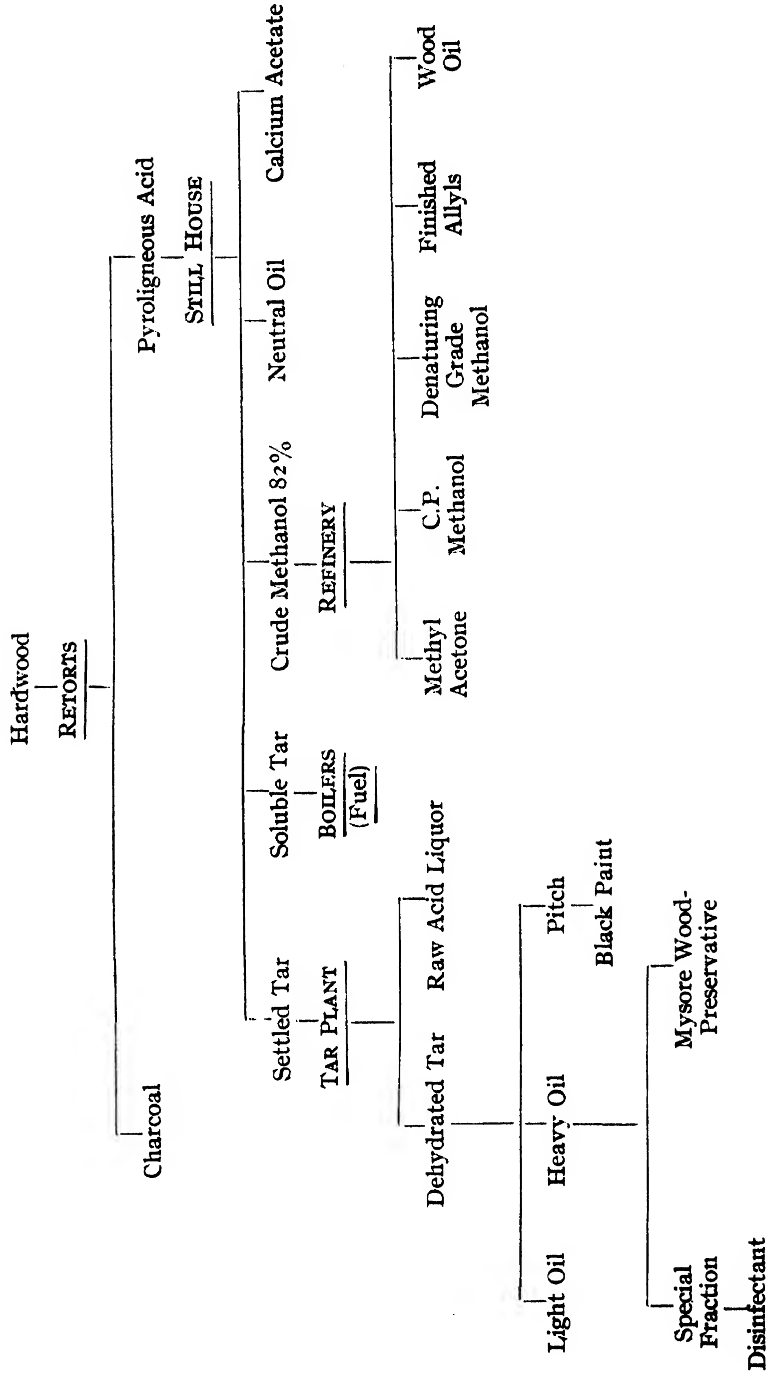
The methyl acetone, as noted above, is used as a solvent in various industries, while methanol is used in the manufacture of formaldehyde or formalin, and in the dye industry. It is also used in the manufacture of paints, varnishes, and polishes.

A flow sheet showing the various products obtained by the destructive distillation of wood as carried out at Bhadravati is reproduced on the following page by courtesy of the Mysore Iron Works, Bhadravati, Mysore, and will no doubt help to make the method of production of the various products more clear.

India has available in her forests copious supplies of hardwoods, and it would appear at first sight that a wood distillation plant would be a paying

MYSORE IRON WORKS

PRODUCTS' FLOW SHEET



proposition. A very cursory examination of the question shows however that such is not the case.

In the first place the main product produced by a wood distillation plant is charcoal, and the plant should be able to pay its way by the sale of charcoal alone, any profit derived being obtained by the sale of the by-products. The amount of charcoal produced by a destructive distillation plant of any size is very large; in Mysore the production is no less than 60 tons per day. Charcoal is a product which does not lend itself to profitable transport, being bulky for its weight and subject to damage and loss during transit. This difficulty could possibly be overcome by briquetting the charcoal, but even then it would be difficult to obtain a profitable market for such large supplies. At Bhadravati the plant is run mainly for the charcoal which is used on the spot in blast furnaces for the manufacture of iron from iron ore, and the question of its sale does not therefore arise.

Secondly, there is no market in India for the by-products of wood distillation, as there are not sufficient industries to absorb the supplies which one factory could produce. Even the acetate of lime and refined alcohol products from the Bhadravati plant find little or no sale in India and are exported to Japan and England.

Finally, the competition of synthetic products is growing keener every day. This competition has been felt by many wood distillation plants in Europe and America, and some of them have actually had to close down.

When these considerations are taken into account, it will be evident that a destructive distillation plant is not likely to be a paying proposition in India, under present conditions.

It is possible, however, that a recent development in the wood distillation industry, namely the direct conversion of the pyroligneous liquor into acetic acid *without going through the intermediate stage of lime acetate,* may make a considerable difference to the industry.

This new process was discovered by Suida, an Austrian professor, and his process is now being worked by two small plants in France and Yugoslavia, and an American plant is also trying it on a factory scale. If the process proves successful, it will greatly reduce the cost of manufacture of acetic acid, which is used in large quantities in Ceylon, Java, and the Malay States in the rubber industry. It is still possible, therefore, that India may find it profitable to manufacture acetic acid for these countries, which are much nearer to her shores than those of Europe and America.

Chir tar

From the old stumps and roots, and to a lesser extent from the boles and branches, of felled chir (**Pinus longifolia**) trees a highly resinous wood, locally

known as *chilka*, is obtained. By subjecting this *chilka* to a form of crude destructive distillation in an improvised retort, a product known as chir tar is obtained. A profitable industry in this product sprang up during the Great War, when it was found that this tar was a fair substitute for imported Stockholm tar, imports of which were at that time rendered difficult on account of the war. Large quantities of Stockholm tar are imported yearly into Calcutta, where it is used in the jute mills for tarring ropes, etc.

No less than 1,458 maunds of this chir tar were produced in the Kumaon hills in 1919-20, but after that the market began to disappear, and production had finally to cease altogether, as the result of a return to normal conditions of trade in Stockholm tar.

Attempts have been made at various times to find another market for chir tar, but it was not till 1929 that proposals were put forward to utilize the tar as a local road-surfacing material to replace other proprietary compositions. Experiments showed that chir tar was unsuitable for the purpose in a crude state. As the result of investigations at the Forest Research Institute a product was however evolved from chir tar and was given the name of 'Pintar', and it was thought that this might prove successful as a road-surfacing material. Practical tests on a stretch of the Bareilly-Almora road have shown, however, that this was not the case with the material as prepared. 'Pintar' lacked the necessary penetration and proved too brittle, with the result that it broke up badly. Further, the 'Pintar', as used, did not compare favourably in price with other road compositions.

Deodar tar oil

By destructive distillation of the wood of **Cedrus deodara**, a thick tar-like oil is obtained which is used for rubbing on the inflated skins (*sarnai*) commonly used in India for crossing rivers; and as a remedy for ulcers and eruptions, for mange in horses and sore feet in cattle. It is also used to some extent for cremations. This tar is usually locally prepared and is generally procurable in bazaars adjacent to deodar forests.

PLATE XIII Chir tar still in Almora District, U.P. *Facing p. 264.*

XIV

OILSEEDS

Bassia latifolia—*Bassia butyracea*—*Schleichera trijuga*—*Chaulmugra* oil—*Mesua ferrea*—*Shorea robusta*—*Pongamia glabra*—*Garcinia indica*—*Calophyllum inophyllum*—*Vateria indica*—other oilseeds—waxes.

There are a very large number of forest trees which bear seeds yielding oils of varying commercial importance. Some of these oils, or 'butters' as they are often called, have already established a good market for themselves, but the majority are of local importance only, although some of these deserve better attention on account of their richness and quality. Owing, however, to the scattered nature of most Indian trees, and the consequent high cost of collection of their seeds on a large scale, forest oilseeds can seldom compete with oilseeds produced as field crops, such as linseed, sesamum, mustard, and rape. They are used nevertheless by villagers and forest dwellers for multitudinous purposes, of which the chief are cooking, lighting, and the adulteration of more expensive oils.

There are two main methods of extracting oil from seeds. These are known as expression and extraction.

In the former case the seeds are first screened or sieved to remove impurities such as sand, stones and pieces of wood, and when necessary the seeds are decorticated, an operation consisting in cutting the shell with knives fixed on a revolving member and adjusted so that only the shell of the seed is affected. The kernels when separated from the split shells are crushed by being passed between chilled iron rolls.

If the oil is to be cold pressed (cold drawn), the crushed seeds are placed in hydraulic presses consisting in principle of two metal plates or tables, one of which is fixed and the other movable. The seed is placed in the interspace and pressed, and the oil is forced out by the pressure between the plates. This operation is known as expression. A higher yield of oil is obtained by heating or cooking. In this case the crushed seeds are placed in a kettle provided with a steam jacket and a mechanical stirrer to ensure uniform heating. The steam jacket is heated and a certain amount of steam is blown into the mass in order to moisten it to the required degree. The oil is then expressed from the heated mass in a hydraulic press.

The same principles are followed in expressing oil by 'country' methods in India, but in this case the operation carried out by machinery in modern factories is done by hand. The hydraulic press is replaced by the ordinary *ghani* or 'country' press.

The other method of obtaining oil from seeds, namely extraction with volatile solvents, gives the highest yield of oil of all processes, but the resulting cake is not fit for cattle feeding, both on account of its low fat content and also because traces of the solvent are usually present and are very difficult to remove entirely. For this reason, extraction by volatile solvents is generally only practised when the seed is naturally unsuitable for a feeding-stuff or is of very low value for this purpose, or when the seed is in a damaged or fermented condition. In the process of extraction, the crushed seed is placed in an apparatus known as an extractor. There are two types of extractors commonly used, namely (1) where the solvent is continuously distilled off, condensed and returned to the extracting vessel, and (2) where a constant supply of solvent flows through a series of vessels containing the material to be extracted and as the vessels become exhausted they are cut out of the series and recharged. The solvent issuing from the end extractor contains a high percentage of the oil extracted. The solvent is then separated from the oil by being distilled off and is returned to the store tank. The solvents commonly used are petroleum ether, carbon disulphide, and chloro-derivatives of hydrocarbons, the first being the most generally employed.

The oils extracted by both processes are then clarified and refined in various ways.

Although most of the Indian tree seed oils are of little commercial value, they are important from an economic point of view, and it is proposed therefore to give a brief description of some of the best known.

Bassia latifolia

From the seeds of **Bassia latifolia** an oil is extracted which is known in commerce as *mohwa* butter. The kernels of the fruit are removed from the smooth chestnut-coloured pericarp, by being bruised, rubbed and subjected to moderate pressure. They are then ground, and the oil is obtained by expression, the yield being in the region of 40 per cent. This oil is used extensively in India for adulterating *ghee*, for cooking purposes and for soap-making. It is also used by hill tribes for burning.

Bassia longifolia replaces *Bassia latifolia* in the south of India and is there known as *illupei*. The seeds are used in the same way and for the same purposes as those of *Bassia latifolia*. The seeds of both *Bassia latifolia* and *Bassia longifolia* are exported to Europe, where they are said to be used for soap-making and also

for the manufacture of artificial butter or margarine. The cake left after expressing the oil is said to be poisonous to cattle, owing to the saponin which it contains, and consequently it fetches a low price. It is used as a field manure instead of as a feeding-stuff for cattle. It is also used for washing the hair, as a cheap substitute for *shigakai* (*Acacia concinna* fruits), by the poorer classes in parts of Madras.

Bassia butyracea

Bassia butyracea, known as the Indian butter tree, extends along the sub-Himalayan tracts from the Ganges to Bhutan. The seeds yield an oil known as *phulwa* oil, which is obtained by beating the seeds into a paste of the consistency of thick cream and squeezing out the liquid portion by placing weights on it. The oil has the consistency of *ghee* at all ordinary temperatures and is of a delicate white or grey colour. It is superior to *mohwa* butter in that it remains sweet for a very long time whereas the latter is liable to go rancid.

Schleichera trijuga

Schleichera trijuga is found in the deciduous forests of India and Burma and is well known as one of the best host plants for the cultivation of lac. It produces seeds yielding the *kusum* oil of commerce. The yield of oil in the kernels varies from 57 to 80 per cent. It is a yellowish-brown oil used for cooking and lighting purposes and has been found suitable for soap-making. It is reputed to be the original Macassar oil, possessing properties for cleaning and promoting the growth of hair.

Chaulmugra oil

Chaulmugra oil has long been used in India for leprosy and skin diseases and is now an important drug in European and American markets, as it is a recognized cure for leprosy. It is injected into the patient and is also applied externally. This oil is obtained from the seeds of **Taraktogenos kurzii**, a tree found only in parts of Assam, Chittagong, and Burma. This tree was at one time the only source of *chaulmugra* oil, but recent investigations have shown that a similar oil is produced from the kernels of the seeds of various species of **Hydnocarpus**, the most important of the Indian species being *Hydnocarpus wightiana*, a tree found in the forests of the Malabar coast, and *Hydnocarpus alpina*, a large tree common in the sholas of the eastern side of the Nilgiris and throughout the Western Ghats.

It is now generally accepted that the best *chaulmugra* oil is produced from seeds of the various *Hydnocarpus* species, as they are less liable to fermentation, with consequent rancidity of the oil, than the seeds of *Taraktogenos kurzii*.

Mesua ferrea

Mesua ferrea, the ironwood tree, which is found in Burma and Assam and also on the East and West Coasts of India, possesses a rich oil-yielding seed. The yield of oil is extremely high, being as much as 70 per cent of the original weight of the kernel. The oil is reddish-brown in colour and has a slightly unpleasant odour. It is used for burning, lubricating, soap-making and for applying to sores. The residual cake has a bitter flavour, and in view of the fact that the kernels are said to contain a poisonous acid resin which is soluble in the oil and appears to act as a heart poison, the cake cannot be utilized as a food for cattle.

Shorea robusta

The cotyledons of the seed of **Shorea robusta** yield the well-known sal butter. The seeds are husked and boiled and the oil is skimmed off the top of the water and soon solidifies to a white butter. It is used for cooking and lighting and the adulteration of *ghee*. The seeds are sometimes eaten whole, especially in times of famine.

Pongamia glabra

Pongamia glabra, found in Central and South India, produces seeds yielding a yellow-brown oil of local importance. It is used in medicine and as an antiseptic and has been used to some extent as a lamp oil in Indian villages for a long time. Of late the oil has fallen into disuse for burning purposes as a result of the severe competition of kerosene. Recent experiments have shown that the oil is suitable for soap-making. The oil has a disagreeable smell which persists for a long time, but finally a pleasing aromatic smell resembling that of benzaldehyde is developed. It is possible therefore that soap made with an admixture of this oil and other oils and fats might eventually be prized on account of the aromatic odour which is developed without the use of any perfume.

Garcinia indica

The seeds of **Garcinia indica** yield kokam butter, sometimes known as mangosteen oil. It is found in Indian bazaars in egg-shaped solid lumps and is used in the preparation of ointments and as a nutritive medicine.

Calophyllum inophyllum

Calophyllum inophyllum, a large tree of the West Coast, produces a dark-coloured fruit, the kernels of which are rich in fatty oil. This oil is used for burning and for soap-making. When mixed with the resin of *Vateria indica* it is used for caulking boats on the West Coast. It is not suitable as an edible oil owing to the presence of toxic constituents.

Vateria indica

The seeds of **Vateria indica**, a tree found at the foot of the Western Ghats from Kanara to Travancore, give a solid oil known as piney tallow. The seeds are roasted, ground, boiled with water and the oil skimmed off. Piney tallow is tasteless and inodorous; it has first a pale yellow colour, but gradually becomes quite white. It is used for lighting purposes, as a substitute for *ghee*, and for medicinal purposes, the oil having obtained considerable repute as a local application for chronic rheumatism. It is also used locally for the manufacture of candles. The seeds are exported in small quantities to Europe where the tallow is said to be used in the manufacture of soaps and candles. It is also said to be edible after refining, and suitable for use in making confectionery. It has been suggested that piney tallow might be used to replace the animal tallow now employed for making size paste used in yarn weaving.

Other oilseeds

Other oilseeds of varying importance are obtained also from *Mimusops elengi*, *Juglans regia*, *Melia indica*, *Celastrus paniculata*, and *Prunus* spp.

Waxes

In addition to the above, some tree seeds produce a wax which is useful for burning purposes. Amongst these are **Sapium sebiferum**, the Chinese tallow tree, which is found extensively, planted and wild, in North India. The seeds of this tree are coated with a white wax used in China for the manufacture of candles and soap and for dressing cloth. This wax is not however utilized to any great extent in India as the cost of collection is prohibitive.

Another wax-producing seed is that of **Rhus succedanea**, a small tree of the Himalayas. The seeds are crushed, boiled, and mixed with the oil of *Melia azedarach* fruits, producing a wax which is made up into candles which are sold under the name of Japan wax.

XV

TANS AND DYES

TANS

Bark Tans; babul—*tarwar*—sal bark—*Terminalia arjuna* bark—*Cassia fistula*—other tan barks. **Fruit Tans**; myrabolams—babul pods—divi-divi—*goth-bor*. **Leaf Tans**; *Anogeissus latifolia*—*Carissa spinarum*—other leaf tans and galls.

DYES

Wood Dyes; santaline—brazilin—*Artocarpus* dyes—cutch dye. **Bark Dyes**. **Flower and Fruit Dyes**; kamela—arnotto—*dhak*, etc. **Root Dyes**. **Animal Dyes**.

TANS

The name tannin is given to organic substances which have the property of combining with albumen and gelatine to form an insoluble compound which will resist decay. Raw animal hides treated with tannin are converted into the decay-resisting material known as leather.

Bark Tans

Forest trees with barks yielding useful tanning materials are very numerous in India. The bark is generally obtained from trees felled under the ordinary annual cut, as the stripping of standing trees outside the regular felling areas is obviously very harmful to the trees. There is a difference of opinion as to whether bark from old or young trees is best for tanning purposes, but vigorous stems contain more tannin in their bark than those of poor growth, and the beginning of the growing season is the most favourable time for collecting the bark, as it strips off more easily at this time and the percentage of tannin it contains is then highest. After the bark has been removed from the tree, it is cut into convenient lengths and dried by standing the pieces on end against each other or against a rough trestle so that the outer bark is uppermost. This should be done in fine weather or under cover as continuous rain washes out the tannin. The bark is usually dry enough at the end of 3 or 4 days to be dispatched to its destination.

In former times, hides were tanned by being placed in alternate layers with ground bark, but as this process usually took about 2 years before the hide was properly tanned, it has been superseded by the use of tan-extracts or tan-liquors which are extracted from the raw materials, and which complete the tanning

process in a much shorter period, ranging from about one to five months. Tan liquors are leached out of barks, or other raw materials, by the application of steam in specially prepared wooden vats, and can be purified and mixed with other extracts to give any required colour or quality of leather. This last point is of importance as the best tan barks are very often rendered unsuitable on account of the objectionable dyes they contain.

Babul

The most important bark now used by tanners, especially in Northern India, is that of **Acacia arabica**, the babul tree. It is a common tree found in forests, on waste areas, and on cultivated lands. The chief areas producing babul bark in commercial quantities are the Berar Circle of the Central Provinces, where it is the chief species on black cotton soils, and in Sind and the Central Circle of Bombay, where it forms riverain forests. In the United Provinces and the Punjab it is a common tree, but is usually found widely scattered over waste and cultivated lands. Babul trees are generally sold standing to contractors who strip the bark, dry it, and dispatch it in bundles to the tanning factories. The most important centre of consumption is Cawnpore, and most of the babul bark of India finds its way to the leather factories situated in that district. The chief claim of this bark is its cheapness and abundance. The tannin present in the bark varies considerably and may be as high as 20 per cent, but the average content of bark delivered to the tanneries is usually about 12 per cent, while the soluble non-tans amount to about 8 per cent. The leather produced by babul bark possesses firmness and durability in a high degree, but exhibits harshness and is dark-coloured. Babul bark is bulky and the percentage of tannin is comparatively low so that, although it is likely to remain a tanning material of great local value, it is one that stands a poor chance of being exported in large quantities.

Tarwar

This bark, known in Tamil as *avaram*, is obtained from **Cassia auriculata**, a small bush which grows wild in the south and west of India. It is also found in the dry zone of Upper Burma. It thrives on dry stony hills and black soils and is common on roadsides and similar waste land. The method of collection consists in cutting off at the base the branches and twigs which spring from the roots. The coppiced bush sends out a large number of shoots, and a new harvest can be taken year after year. The stripped bark dries in small cornets, and the product usually delivered to the tanneries contains on an average about 18 per cent of tannin and 10 per cent of soluble non-tans. The bark from old

plants may contain as much as 23 per cent of tannin, while that from young plants may contain only 12 per cent or even less.

The success of the tanning industry in Madras is regarded as almost entirely due to the peculiar qualities of *tarwar* bark and to the fact that supplies have been available in the past at low prices. The tannin from this bark penetrates the hide quickly and produces a special form of leather, lightly tanned, with an elastic grain, of pale colour and with good tensile strength. This half-tanned leather, known as East Indian tanned hides, is exported to the United Kingdom where its tannage and preparation for a variety of uses are completed. The special feature of *tarwar* bark is that it is very easy to use, and in spite of the carelessness which is so often manifest in its application by Indian tanners, it yields uniformly successful results. During the war of 1914–18 the enormous demand for the bark, due largely to the increased output of South Indian tanneries, caused many areas to be stripped in such a way that the supply was seriously affected. In addition, the cost of labour has now increased to such an extent that the price of the bark has risen. The result has been that this bark is being replaced more and more by wattle (*Acacia mollissima* syn. *Acacia decurrens*, var. *mollis*), imported from South Africa. The cultivation of wattle bark is now an important industry in South Africa and the bark is offered at attractive rates. Plantations of *tarwar* have not been successful in India.

Sal bark

Large quantities of the bark of sal (**Shorea robusta**) become available during felling operations, and it has long been used successfully as a local tanning material. The bark contains from 3 to 9 per cent of tannin and furnishes a very tough reddish-coloured leather.

Terminalia arjuna bark

Terminalia arjuna is a large tree occurring on banks of rivers and streams throughout Central and Southern India and extending as far north as Oudh. The bark of this tree, which has been employed for many years for local tanning, was first introduced into the tanneries at Cawnpore in 1915 and has since become a well-established and important tan stuff. The dry bark from the stem contains from 20 to 24 per cent of tannin and the dry bark from the lower branches about 18 per cent. *Terminalia arjuna* tannage is capable of wide application and can be used for the production of fine upper leather and excellent sole leather. The colour of the leather is light brown with no excessive red tint.

Cassia fistula

Cassia fistula produces a bark known as *sunari*, which is also extensively used for tanning but is not considered so good as *tarwar* bark. The tree has a wide

PLATE XIV. Common Indian tan products

1. *Acacia arabica* (babul) bark
2 & 3. *Terminalia chebula* myrabolams
4. *Terminalia belerica* myrabolams
5. *Cassia auriculata* (*tarwar*) bark

Facing p. 272.

distribution, being found all over India, Burma, and Ceylon, and is commonly known as the Indian laburnum or *amaltas*. The trade in this bark is also dwindling on account of competition with African wattle bark.

Other tan barks

The only other barks of outstanding importance which give tanning agents of commercial value are those of the mangroves or evergreen trees of the Sunderbans and tidal creeks of India, Burma and the Andamans, and the chestnuts of the Himalayas and North Burma. Of these, **Rhizophora mucronata** is perhaps the best known. The bark is rich in tannin, but the dye matter is held to be excessive. The extract from mangrove barks is also known as cutch in commerce. Apart from its use in local tanneries Indian mangrove bark is not likely to enter the world markets as it is not so rich in tannin as mangrove barks from other tropical regions. A Government factory for preparing an extract from this bark in Burma was closed down in 1905. **Ceriops candolleana** and **roxburghiana** are two other evergreen trees, common in the tidal forests of Burma and the Andamans, producing useful tan-yielding barks.

A very great variety of other trees yield tan barks of varying local importance, amongst which may be mentioned *Bridelia retusa*, *Acacia leucophloea*, *Terminalia tomentosa*, *Tamarix articulata*, *Lagerstroemia* spp. and the oaks of India and Burma.

Fruit Tans

Of equal importance with bark tans, and yielding a greater revenue to the Forest Department, are certain tree fruits which are used for tanning purposes and for preparing tan extracts.

Myrabolams

By far the most important of these is the fruit of **Terminalia chebula**, known commercially as the chebulic myrabolam. Two other myrabolams are known in commerce, namely the beleric myrabolam from **Terminalia belerica**, and the emblic myrabolam from **Phyllanthus emblica**, but neither of these compares favourably with the first-named, and when speaking of myrabolams the fruit of *Terminalia chebula* is usually understood. The tree occurs in Madras, Bombay, the Central Provinces, Bengal, Northern India, and Burma mainly on village lands, and very large quantities of myrabolams are exported to Europe from the three first-mentioned provinces. The average export over a period of years is in the vicinity of 60,000 tons per annum, valued at over 70 lakhs of rupees. It will be realized therefore that myrabolams are very important forest products.

Five different commercial varieties of chebulic myrabolam are known in the English market. These are named after the districts from which they are marketed, two grades of each variety generally being available. The prices obtained vary according to the quality and source of supply.

The five varieties are:—

(1) Bhimlies, from Bimlipatam in Madras.
(2) Rajpores, from Kolhapur State.
(3) Jubbulpores, from Jubbulpore in the Central Provinces.
(4) Vingorlas, from the Bombay forests.
(5) Madras Coast.

Some uncertainty seems to exist as to the best time for gathering myrabolam fruits. Bhimlies and Jubbulpores, which are the most esteemed varieties, are generally collected in a green unripe condition. Bombay fruits, on the other hand, are gathered when ripe, but as a rule they are not so much in favour with tanners although they frequently contain a higher percentage of tannin. The percentage of tannin in myrabolams varies considerably, but in dried fruits it is usually between 25 and 40 per cent. An investigation as to the best time for collection has shown that the highest percentage of tannin is present in ripe fruits. The commercial value of myrabolams is, however, not governed solely by the amount of tannin they contain, but depends also on various other qualities which render some varieties more suitable than others for producing certain classes of leather. For instance, Jubbulpores have been shown to be the most valuable for weight-producing.

On the other hand, the difference between the well-known commercial varieties is not always based on any scientific distinction but is more often the result of popular prejudice. Some tanners state that myrabolams from a certain locality suit their purpose better than others, but there is apparently very little reason, in a great many cases, for such distinction.

Myrabolams are one of the most important tannin materials of the pyrogallol class, a class of tans which produce a brownish-coloured deposit on leather called bloom, as opposed to the other class of tans, the catechol class, which do not produce this bloom. Myrabolam tannin is not very astringent and penetrates the hide slowly. When used alone it produces a soft, mellow, and rather spongy leather which does not possess good wearing properties. It is, therefore, usually blended with other astringent and quickly penetrating tannins such as quebracho, wattle, and mangrove, the red colour of which is thereby neutralized, and a brighter and more satisfactory colour is imparted to the leather. In India, myrabolams are largely employed in conjunction with babul (*Acacia arabica*), *tarwar* (*Cassia auriculata*) and mangrove barks. They are not, as a class,

considered a good weight-giving tan-stuff, and the proportion of tannin combining with the hide substance is small when compared with other tanning materials.

Myrabolams are also employed as a mordant in the dyeing of cotton and for the weighting of black silk and in the manufacture of ink.

The whole, sun-dried, fruits are generally picked over before being shipped in bags, as they are very liable to rot during storage if not properly looked after. As the stones of the myrabolams constitute from about 20 to 50 per cent of the fruit and contain only about 2 to 4 per cent of tannin, their removal would result in a product containing about 20 per cent more tannin and would at the same time effect a considerable economy in freight. Although considerable quantities of crushed myrabolams are exported from India, they have failed to find favour with British tanners largely owing to the fact that material of this kind lends itself to adulteration and to contamination with unsound fruits. Further, preference is given by different tanners to certain varieties and grades of myrabolams, and without being able to handle the whole fruits they can never be certain of obtaining the grade they require.

In addition to the whole fruits and crushed myrabolams, solid extract of myrabolams has also been a popular and regular article of commerce. Most of this solid extract is prepared in an extract factory in Bengal, and is exported in the shape of solid blocks containing 50 to 60 per cent of tannin. It is stated, however, that the solid extract furnishes a far less satisfactory tanning material than the fruits themselves, especially with regard to the formation of acid liquors and improvement in the colour of the leather. For this reason tanners prefer as a rule to make for themselves a liquor extract containing about 30 to 35 per cent of tannin, and considerable quantities of myrabolams are now utilized in this way.

Babul pods

Another tan-fruit of local importance is the pod of **Acacia arabica**, the babul tree.

Babul pods are sought after by tanners, not only for the tannin material they contain but also on account of the good colour they give to, and the softening effect they have on, leather. Large quantities are sold annually in Sind, and to a lesser degree in Bombay and the United Provinces, but the pods are not exported on account of the high cost of freight, their tendency to ferment, and the low percentage of tannin they contain.

Divi-divi

Another tree producing tan-pods is **Caesalpinia coriaria**, which yields the divi-divi pods of commerce. This small tree is a native of South America and

the West Indies, but it has been introduced into India and is now commonly cultivated in Bombay and Madras. The bulk of the world's supplies come from Central and South American countries, and within the British Empire much smaller quantities are available from India (Madras) and Jamaica. The pods contain from 40 to 45 per cent of tannin, the tannin in the pods being located in the tissue lying just beneath the epidermis.

When used alone in tannage, divi-divi pods yield a leather which is strongly affected by climatic conditions. In damp weather it is spongy, while in drought it loses its pliability. The pods are, therefore, usually blended with other materials.

On account of the high percentage of glucose in the pods the liquor is liable to ferment, while at times it suddenly develops a deep red colouring matter. The use of antiseptics has been found to prevent the latter change. Tanners in the United Kingdom are prepared to use greater quantities of divi-divi pods and would welcome increased supplies. Extension of cultivation can therefore be recommended, as the product would find a ready market.

Goth-bor

The only other tan-fruit of any importance is that of **Zizyphus xylopyra**, the *goth-bor* tree. It is a small tree found in most parts of India and its fruits are used to give a black colour to leather.

Leaf Tans

Leaves are not extensively used for tanning purposes, and from a forest point of view are not very important as tan agents, and are only used by local tanners. There are, however, two leaf tans which received a certain amount of attention during the Great War, namely *Anogeissus latifolia* and *Carissa spinarum*.

Anogeissus latifolia

Anogeissus latifolia is a large deciduous tree met with in the sub-Himalayan tract from the Ravi eastwards to Central and Southern India. The leaves of this tree have been known and used locally for many years under the name of *dhawa* sumach. The dry, mature leaves contain about 16 per cent of tannin, whereas the dry reddish tips of young leaves have been found to contain up to 55 per cent. Experiments have shown that a mixture of green leaves, red leaves and petioles, when dried and coarsely ground to pass through a 10-mesh sieve, yield a product containing 30 per cent of tannin and 16 per cent of soluble non-tans. The tannin penetrates rapidly and produces a satisfactory pale-coloured leather with a greenish tinge.

Although *dhawa* sumach is a good tan stuff there are considerable difficulties about collecting it. It is only the young reddish-coloured leaves that contain a high percentage of tannin, and there is only a short period between the appearance of the young leaf and the break of the monsoon, when the risk of damage from damp is great. The leaves have to be carefully dried if fermentation, with consequent reduction in the tannin content, is not to set in, and this is almost impossible once the monsoon has broken. Further, it would be easy for an unscrupulous contractor to make *dhawa* sumach entirely from other species without any expert being able to tell the difference till it was used in the tan pits.

This material has recently been investigated by the Imperial Institute in London and has been well reported on, and they wish to make large-scale trials to determine whether it can replace true sumach in the preparation of light leathers. It is not, however, likely to find a market in England owing to the high cost at which it can be offered—about £20 per ton f.o.b. Indian ports. *Dhawa* sumach is never likely, therefore, to prove a commercial proposition, but it will always be a tan stuff excellently suited for village tanners who can collect it in their own districts under their own supervision.

Carissa spinarum

Carissa spinarum (*karaunda*) is a thorny evergreen shrub which occurs in most parts of India and especially throughout the central and northern parts.

Karaunda leaves are less variable than *dhawa* leaves as regards tannin percentage, but it is even more difficult to collect them free from twig and fruit. The tannin percentage is low (9 to 11 per cent), but it has the advantage that the leaves can be collected all the year round. The tannage is slow, causing extreme swelling of the hide, and if care is not taken 'drawing' of the grain takes place. Very satisfactory results are, however, obtained with admixtures with other tan stuffs. The twig bark of *Phyllanthus emblica*, for instance, has been found to be an ideal ingredient to mix with *karaunda*, as its red effect neutralizes the greenish coloration produced by the *Carissa spinarum* leaves.

Other leaf tans and galls

Other well-known but not very important leaf tans are afforded by **Phyllanthus emblica**, **Lawsonia alba**, and **Rhus cotinus**. The leaves of **Hopea odorata**, a common Burma tree, are known to yield a sumach of exceptional value but these have not yet been exploited.

Leaf-galls are found on several Indian trees and are used locally for tanning purposes. The best known are the galls of **Tamarix spp.**, **Garuga pinnata**, **Prosopis spicigera**, and **Terminalia spp.**

DYES

Wood Dyes

Since the introduction of aniline dyes, the value of formerly important vegetable dyes obtained from forest trees and plants has been greatly reduced. There are, however, a considerable number of these dyes, and although most of them are now of local interest only there are still a few which retain their former importance.

Santaline

One of the best known of these is santaline dye from **Pterocarpus santalinus**, the red sanders tree of Madras. The wood of this tree yields a bright red dye used as a colouring agent in pharmacy, for dyeing leather and staining wood, and when dissolved in alcohol it dyes cloth a most beautiful salmon-pink colour.

Brazilin

Caesalpinia sappan wood also yields a valuable red dye, known commercially as brazilin, but it is doubtful whether the supply from India, owing to the scattered distribution of the tree, will ever be able to compete with the same product from Brazil, where the industry is an old and well-established one.

Artocarpus dyes

The wood of the jack tree, **Artocarpus integrifolia**, as also that of **Artocarpus lakoocha**, if ground to powder and boiled in water, yields a bright yellow dye used for colouring cloth and especially for dyeing the robes of Buddhist monks in Burma.

Cutch dye

The dyes mentioned above are the more important wood dyes used in India at the present time, but the use of cutch extract from **Acacia catechu** must not be overlooked. This extract is by far the most valuable dye-agent that India possesses and has been fully described on pages 255–8. It has the valuable property of being a tan extract as well as a dye-agent, but its great value comes from its preservative qualities when used for tanning and dyeing canvas, leather, or cloth for marine purposes.

Bark Dyes

Many barks yield brown and black dyes, but as the same barks are often used for tanning purposes, the dye contained in them is, more often than not, considered a defect rather than an asset.

Bark dyes are not important, but the following may be mentioned as being of local interest: *Terminalia tomentosa*, *Berberis nepalensis*, *Acacia* spp., *Alnus* spp., *Mimusops littoralis*, *Myrica nagi*, the box myrtle of Burma, *Ventilago madraspatana*, and *Casuarina equisetifolia*, the bark of which is used by Madras fishermen for dyeing their nets.

Flower and Fruit Dyes

More important, generally speaking, than wood, bark and root dyes, are the natural dyes obtained from the flowers and fruits of many forest trees. The right of collecting these flowers is usually farmed out to contractors or to merchants, who employ regular collectors from the neighbouring villages. The number of species in the forests of India yielding flower dyes is very large and probably runs into many hundreds, but of these only a few are of real revenue-producing value, the remainder being of local interest only.

Kamela

One of the best-known flower (fruit) dyes is that obtained from the red glands on the surface of the capsule of **Mallotus philippinensis**, and known commercially as kamela powder. The tree is a small one with a fluted trunk and is fairly common throughout India and Burma, especially along the sub-Himalayan tracts. Kamela powder is usually obtained by placing the ripe fruits in a cloth or sack, and beating and shaking the sack until the red powder is all removed from the glands. The powder is then sifted free from the broken refuse and is ready for marketing. It can also be obtained by rubbing the fruits between the hands, or by stirring them in water and drying the powder sediment. The dye is extensively used for dyeing silk a bright orange or flame colour and, mixed with other ingredients, the colour can be toned from pale yellow to dark red. The dye was at one time exported in fair quantities to Europe, but with the introduction of aniline dyes the export trade weakened considerably. Kamela powder is also used as a vermifuge in veterinary practice. There was, however, a distinct revival in the export trade a few years ago, the bulk of the supplies going to Hamburg (Germany). In 1929-30, prices in the United Provinces showed a steady rise from Rs110 to Rs125 per maund of 103 lb., the prevailing prices in the previous year having been Rs70 to Rs100 per maund. The demand has however gone down considerably since.

Arnotto

Another well-known dye is the arnotto dye of commerce, obtained from the pulp surrounding the seeds of **Bixa orellana**, an American tree now extensively cultivated in South India. The dye is obtained by boiling the fruit pulp and

pressing the residue into cakes, the form in which it is usually exported. The dye gives a beautiful pink colour to silk and cloth, and when mixed with kamela powder can be toned up to a vivid orange-red. It is exported to Europe where it is employed, amongst other uses, for colouring cheese and butter.

Dhak, etc.

Another popular flower dye is that obtained from the well-known *dhak* tree or Flame of the Forest, **Butea frondosa**. The dried flowers yield a bright yellow dye which is extensively used for colouring Indian *saris*, but when used by itself, the dye is not very permanent and has been supplanted to a large extent by the more permanent aniline dyes.

Amongst other flower and fruit dyes may be mentioned those of **Ochrocarpus longifolius**, yielding a red dye used for colouring silk, **Wrightia tinctoria**, the seeds of which produce a blue colouring agent similar to indigo, and the flowers of **Cedrela toona**, **Nyctanthes arbor-tristis**, and **Michelia champaca**, all of which yield yellow dyes, used for colouring silks and cloth.

Root Dyes

Here again, there are numerous forest trees and plants whose roots yield dyes of varying quality, but the majority are unimportant from a forest point of view and are only used locally by villagers who are unable to procure anything better.

The most commonly used are those obtained from the roots of **Berberis aristata**, **Morinda tinctoria**, **Symplocos spp.**, **Datisca cannabina**, and **Punica granatum**, all of which yield dyes of yellow and red shades.

Animal Dyes

Animal dyes are not usually considered worthy of mention under forest products, but there is one dye which, although no longer important from an economic point of view, deserves mention on account of its interesting associations. The dye referred to is the crimson dye obtained from **Laccifer lacca**, the lac insect. In former years lac dye was an important commercial product, but of late it has gone into disuse owing to the superiority of modern chemical dyes. Its old association still lingers however in the well-known colour crimson lake which was formerly prepared from this dye, the word 'lake' being a corruption of the Hindi word *lakh*.

XVI

GUMS, RESINS, AND OLEO-RESINS

GUMS AND GUM-RESINS

Gum arabic—babul gum—gum kino—Bengal kino—jhingan gum—*katira* gums—moringa gum—*salai* gum—*dhaura* gum—*khair* gum—*Bauhinia retusa* gum—miscellaneous gums.

RESINS

PINE RESINS. RESINS FROM BROAD-LEAVED SPECIES; black dammar—*Vateria indica*—rock dammar—sal dammar.

OLEO-RESINS

Gurjun oil—*in* oil—*thitsi* oil—*Hardwickia pinnata* oil.

Gums, resins, and oleo-resins form an important section of the minor forest products of India. The pine resin industry is now well-established in this country and the revenue therefrom increases annually. Indian gums are exported to Europe in fair quantities, but by far the greater majority of these products are sold in the Indian markets and utilized either in local industries or in the large manufacturing towns of this country. These gums are mainly collected by villagers and persons tending cattle, who dispose of them in the nearest bazaar. From there they pass through many hands before they eventually reach the manufacturer, and during this period they are liable to become mixed and even adulterated. Better prices would probably be obtained for these gums if it were possible to market them in a pure state with a guarantee as to their origin.

GUMS AND GUM-RESINS

It is not possible to draw a distinct line between the so-called gums, gum-resins, resins, and oleo-resins, as the products designated by these names commercially do not always react chemically in the same manner. Broadly speaking, gums are translucent amorphous substances which are degradation products of the cell-walls of woody species and which exude spontaneously from the tree. Exudation is in most cases accelerated by wounds in the bark, and this fact is made use of by gum collectors, who make gashes in the bark or cut thin slices off the outside of the tree to hasten the natural flow of gum.

Spontaneous exudations take place particularly when the bark cracks with prolonged heat, or as a result of unhealthiness. After a long dry hot season large quantities of gum are exuded, especially from unhealthy trees, while after a forest fire exudations are usually very copious. Intensive tapping for gums affects the health of trees to a considerable degree if continued for some years, and it is usual in Reserved Forests to give trees which are being tapped for gums a periodic rest, say for 5 years, after which tapping may be resumed for a further period.

Gums are mostly soluble in water, but if not completely soluble they at any rate absorb water and swell up to form a mucilage or jelly. No gum is soluble in alcohol, and this is the fundamental difference between gums and resins, as most resins are soluble in alcohol but not in water.

Gum-resins are essentially a mixture of gum and resin, formed naturally in the wood-cells by the degradation of the cell-wall and the drying up of the plant juices.

There are a very large number of trees in India which produce gums and gum-resins. Some of these are of considerable commercial importance, but the great majority are of local interest only. A short description will be given of the more important of these gums.

Gum arabic

The true gum arabic of European commerce comes from **Acacia senegal**, but the term 'gum arabic' is often used for other gums, more especially that of *Acacia arabica*, which is more correctly known as Indian gum arabic. *Acacia senegal* is a low shrub-like tree whose main habitat is in Senegal (West Africa) and Egypt, but it is also found in India on the dry stony tracts of Sind, Rajputana, and the Punjab. The Indian trade in gum senegal, as it is sometimes called, is however small, the chief supplies coming from Senegal and Egypt, and this gum cannot be ranked as an important Indian product.

Babul gum

Indian gum arabic or babul gum, from **Acacia arabica**, is on the other hand a product of great commercial value to India. The gum exudes naturally about March and April, and forms into irregular tear-drops about half an inch long and varying in colour from pale straw-colour to dark reddish-brown. Old trees yield more gum than young ones, but the gum from young trees is lighter in colour and considered more valuable. Babul gum is used for a variety of purposes, the chief of which are as a mucilage in calico-printing and sizing paper and as an ingredient in making up whitewashes, paints, and mortars. As a

medicine it is inferior to true gum arabic, but it is used extensively in India in the preparation of native sweetmeats.

Gum kino

Another important Indian gum is the commercial gum kino, produced by **Pterocarpus marsupium**, a large tree of Central and South India. The gum is obtained by making a longitudinal cut down the stem of the tree so that the wood is just exposed. V-shaped side cuts are then made to lead into this central channel, so that the formation has the appearance of a fish-bone. A bamboo tube is placed at the bottom of the main incision, to catch the gum which flows out fairly quickly in a liquid form. Tapping is usually done in the evening, during February and March, and by the following morning the flow has generally stopped. The gum is then removed, before it has time to solidify, to the drying sheds, where it is strained to remove impurities and poured into shallow pans to dry out. When dry, the gum is crumbled up into small grains and is then ready for the market. The yield from each tree is about 1½ lb. of juice which gives about ¾ lb. of dried gum. Good quality gum kino is of a ruby red colour and contains about 75 per cent of tannic acid. It is, therefore, important as an astringent in medicine and is one of the chief medical gums of the world. There is a good export trade in this gum.

Bengal kino

Bengal kino is the product of **Butea frondosa**. The gum exudes from natural or artificial scars and occurs in round tears as large as a pea. The gum has an intense ruby colour, but is usually very impure owing to careless collection. It resembles true gum kino and is used for similar purposes.

Jhingan gum

Jhingan gum, obtained from **Lannea grandis syn. Odina wodier**, is commonly used in India as a mucilage, for making ink, and in the finer parts of stucco work, but it is especially useful to confectioners owing to its great solubility in water, and a certain amount is exported from India for this purpose. The tree is fairly common in North India, and tapping generally starts in March and continues till the rains break. The usual method of tapping is to make cuts in the bark with an axe and the gum exudes in round tear-drops. The yield in the first year is about 5 seers of gum per tree, but at the end of 5 years not more than about 1 seer will be obtained from the same tree. Tapping is, therefore, usually carried on for 5 years and then stopped until the wounds have healed up and the trees have regained their vitality.

Katira gums

The term 'gum-tragacanth' is used in commerce to denote a gum which is not soluble in water but which will absorb water readily and swell up into a mucilaginous mass.

True gum-tragacanth is not produced by an Indian tree, but there are several species in India which produce tragacanth gums slightly inferior to the real thing. These gums are known in India as *katira* or *bassora* gums. The three best known are obtained from **Sterculia urens**, **Cochlospermum gossypium**, and **Bombax malabaricum**, all of which pass under the name of *katira* and are used as substitutes for and adulterants of true gum-tragacanth. The gum of *Sterculia urens* (karar), known as gum *karaya*, is most commonly used for this purpose. These gums usually flow naturally from wound holes due to decay or insects, and in the case of *Bombax malabaricum*, incisions in the healthy bark do not cause a flow of gum. These *katira* gums are all very astringent and are used in medicine, in cases of diarrhœa and dysentery. An increasing demand has arisen in recent years for *Sterculia urens* (karar) gum as an ingredient for face creams and cosmetics, and for thickening ice-cream in America.

Moringa gum

Moringa gum is obtained from **Moringa pterygosperma**. It is a curious deep-red gum which exudes from the tree like drops of blood, and on coagulating forms into a hard dark-red mass. This gum is also one of the tragacanth series but has no great commercial value except for use in native medicines.

Salai gum

Salai gum is the product of **Boswellia serrata**, the Indian olibanum tree. It is a gum-oleo-resin of a greenish-yellow colour and has a pleasant aromatic smell when burnt. It is probably one of the gums which formerly passed as frankincense in Europe, but its present uses are mostly restricted to India, where it is burnt as an incense and used in making up ointments, more especially for rheumatism. The constituents of *salai* gum are an essential oil, a rosin similar to colophony, and a soluble gum. This gum-oleo-resin was investigated in detail in 1912, and on analysis gave 8 per cent of good turpentine, 55 per cent of good quality rosin and 22 per cent of a white soluble gum suitable for sizing and as a thickening agent in cloth printing. In view of the satisfactory results on the chemical side, it was at one time thought that there was every possibility of a profitable industry developing in this product, and one firm actually took up a concession for extracting *salai* gum in the Bombay Presidency. At the time of investigation in 1912, sufficient data were not available from which to estimate the probable cost of collection of the gum-oleo-resin. This aspect was thoroughly investigated by the Forest Research Institute in 1926-7, and it was then

conclusively proved that it would never be possible to collect the gum-oleo-resin at a cost sufficiently low to make it a profitable undertaking under existing conditions. All hopes of a profitable industry developing have, therefore, been given up for the present.

Dhaura gum

Dhaura gum, derived from **Anogeissus latifolia**, is no less important than babul gum from the point of view of both internal and external trade. As met with in the bazaar the pieces of gum are either round or vermicular, opaque externally and transparent internally, and almost free from cracks. The colour varies from whitish yellow to amber. This gum is considered to be superior to babul gum in colour. Under the name of *ghati* gum it is largely sold in Bombay markets, and is extensively used for sizing paper and in calico-printing

Khair gum

This gum from **Acacia catechu** exudes in large tears, pale yellow in colour, and yields a thicker, clearer mucilage than babul gum. It is said that a large proportion of the gum arabic sold in South Indian markets is actually *khair* gum.

Bauhinia retusa gum

The gum of **Bauhinia retusa**, locally known as *semla gond*, was at one time extensively collected in the forests of Dehra Dun and Saharanpur, but of late years collection seems to have fallen off. This is probably due to the trees having become weakened from excessive tapping over a long period of years. This is a clear gum resembling gum-arabic. It is sometimes eaten by the poorer classes and is also used for sizing cloth and paper and for waterproofing terraced roofs. There is always a good local demand for this gum for the above purposes. Recent experiments at the Forest Research Institute have shown that this gum is likely to prove efficient as a binder in the manufacture of charcoal briquettes, when used in conjunction with other binders of a starchy nature.

Miscellaneous gums

Other useful gums are produced by **Acacia leucophloea**, **Buchanania, latifolia**, **Soymida febrifuga**, **Gardenia** species, and **Styrax serrulatum**, which gives a gum benzoin similar but inferior to the true gum benzoin or gum Benjamin of commerce. The latter is produced by *Styrax benzoin*, a tree of the Malay Archipelago. Gum Benjamin is used in medicine, as an incense and as a source of benzoic acid.

RESINS

Resins are usually solid or semi-solid substances, insoluble in water but generally soluble in alcohol. They are formed by the spontaneous evaporation of plant juices or by the activity of special gland cells, and exude from the tree either naturally or by incision of the bark and outer layers of the wood.

For the purpose of classification resins may be divided into two classes:—

(1) Pine resins.

(2) Resins from broad-leaved species.

Pine Resins

There are four pines in India which produce resins of potential commercial value. These are *Pinus longifolia, excelsa, khasya,* and *merkusii.*

Of these, **Pinus longifolia**, the chir or long-leaved pine, is by far the most important from a commercial point of view, and the chir pine rosin and turpentine industry has now become well-established in India. A separate chapter describing the tapping of chir resin and the manufacture of rosin and turpentine will be found on page 324.

Pinus excelsa, the blue pine or *kail*, produces resin less freely than chir, but the turpentine and rosin obtained from it are of a better quality. The more highly resinous portions of this tree are extensively used for torches, in the same way as the wood from chir is so used.

Pinus khasya, the khasia pine, occurs only in the Khasya Hills of Assam, and in Burma. The resin of this species is, in quality, the most valuable of all Indian pine resins and compares very favourably with the best French or American resins. Unfortunately, the khasia pine area in Assam is too small to be of commercial importance, while in Burma the distance of the pine forests from the coast makes the extraction of the resin a matter of considerable difficulty and expense.

Pinus merkusii, the Tenasserim pine, occurs only in Burma. The resin very closely resembles that of *Pinus khasya* in quality, but here again the cost of extraction and conveyance over long distances excludes it from competing seriously with other pine resins from India, America, and France.

Resins from Broad-Leaved Species

Several broad-leaved species in India produce resins of varying utility. These resins are usually described in India under the trade name of dammar. The word is apt to lead to confusion, as true dammar is obtained from *Agathis loranthifolia*, a conifer not found in India.

Black dammar

The resin yielded by **Canarium strictum** is known commercially as the black dammar of South India, the tree being found only in the west and south of the peninsula. It is especially common in Travancore, which is the main source of supply of the dammar. The resin is obtained by lighting a fire round the base of the tree, thereby damaging the bark and outer layers of the wood. This results in a flow of resin some two years later, and the flow, which lasts for about six months every year, continues for about 10 years. This resin, which is of a deep brown colour, is traded all over South India, but owing to its high price it is not much exported. The chief uses of black dammar are for the manufacture of varnish and bottling wax, and it is also used as a substitute for Burgundy pitch for medical plasters. Locally, it is still popular for caulking boats.

Vateria indica

The resin of **Vateria indica** when soft is known as piney varnish, but when the resin is hard it is called dammar or Indian copal. It is a valuable resin obtained in the usual way by incising the tree stem. It is probably the most important Indian dammar from a commercial point of view as it dissolves readily in turpentine, and is consequently in constant demand for the manufacture of varnishes. When the resin is dissolved in turpentine it assumes a turbid and milky appearance, but with the addition of a little powdered charcoal and careful filtering the solution becomes clear and transparent, and when spread thinly it dries with a beautifully clear white surface. Mixed with oil it makes an excellent ointment for application in cases of chronic rheumatism, and on the West Coast it is extensively used, mixed with fish oil and the oil of *Calophyllum inophyllum* seeds, for caulking boats.

Rock dammar

The resin obtained from **Hopea odorata**, a large evergreen tree of Lower Burma and the Andamans, is known commercially as rock dammar. It is a yellow resin of good quality and is employed chiefly in the manufacture of varnish, as a medicine, and as an ingredient of an ointment used for wounds and sores.

Sal dammar

The resin exuded by the sal tree (**Shorea robusta**) is sometimes known in the trade as sal dammar, but the tapping of sal in Reserved Forests has now been prohibited owing to the damage done to the trees. The resin is of a yellowy white colour, opaque, and very brittle. It is sometimes found in large lumps at the foot of the tree and is used for caulking boats, as an incense, and in medicine.

OLEO-RESINS

Oleo-resins, as the name implies, are resins which contain a percentage of natural essential oils. These essential oils are volatile odoriferous oils, generally liquids but sometimes solids, which are found secreted in the intercellular spaces, where they combine with resin formations to produce the exudation products known as oleo-resins. It is also possible to find gum-oleo-resins which contain a percentage of all three products.

Gurjun oil

The most important oleo-resins are obtained from certain species of *Dipterocarpus*, of which **Dipterocarpus turbinatus**, the gurjun tree of Burma and the Andamans, is one of the best known. Gurjun oil is obtained by a method of tapping which does considerable harm to the tree. A pear-shaped cut is made in the trunk, about 3 ft. from the ground. This cut is often 2 ft. long and 1 ft. 6 in. across, and slopes into the tree at the base, so that a receptacle is formed to catch the wood-oil which exudes from the cut surface.

A fire is lit periodically inside the hole if the exudation is sluggish, and this accelerates the flow. As much as 20 lb. of the oleo-resin is sometimes obtained from a good tree in one season. In the Andamans it is collected from January to the break of the monsoon in May, and the flow is always greatest in the hot months. Gurjun oil is exported to Europe in fair quantities and is used there in the manufacture of varnishes and as an ingredient in lithographic ink. In Burma it is said to protect woodwork from insect attack, and for this purpose it is extensively used for smearing on woodwork and bamboo wickerwork, in caulking and varnishing boats, and, mixed with rotten wood, it is made up into torches.

In oil

Another of the *Dipterocarpus* species yielding an oleo-resin is **Dipterocarpus tuberculatus**, which produces *in* oil. It is collected in the same way as gurjun oil, but being of a thicker consistency the cut has to be scraped more often. The congealed resin is much used in Burma, mixed with rotten wood and rolled up in leaves, as a popular form of torch, but compared with gurjun oil the oleo-resin of *Dipterocarpus tuberculatus* is not important.

Thitsi oil

An oleo-resin of great interest and extreme value is that produced by **Melanorrhoea usitata**, the *thitsi* or Burmese varnish tree. The tree is peculiar to Burma and Siam, and the oleo-resin it yields is a natural varnish and one which may be characterized as having originated several distinct art industries peculiar to Burma. The preparation of this crude black varnish is a distinct

forest industry, and wherever the tree abounded, which was chiefly in North Burma, it was rare to find a tree untapped before forest conservancy was brought in. The oil exudes from the inner bark which is cut in V-shaped strips, and a bamboo receiver is fixed at the bottom of the V. It is used in its natural state as a varnish, and, mixed with sawdust or ashes, it forms the body material of Burmese lacquer. It is often used with lampblack, gold leaf, and other pigments, and is applied to the basket foundations of lacquer-ware with a brush, and the finished articles are extremely beautiful, in addition to being serviceable and waterproof. It is also employed as cement and as a medicinal oil, and has the reputation of preserving bamboo and wood from the ravages of insects.

Hardwickia pinnata oil

Hardwickia pinnata, which is fairly common in Mysore, Travancore and parts of Madras, yields an oleo-resin which is popular for the preservation of woodwork, especially in Kanara and Mangalore Divisions. The procedure for tapping is usually on the following lines.

A hole three-quarters of an inch in diameter is bored into trees of 5 ft. girth and over. The hole, which is generally about 3 ft. from the ground, should reach the pith and should slope slightly downwards from the pith to the bark. A lip is then fixed below the hole and a kerosene oil tin is placed beneath the lip to catch the oil which exudes naturally from the wound. The oil, if thin, flows out entirely in one day. When the flow stops the tin is removed and the hole tightly plugged with a piece of wood. Trees are tapped all the year round except during the rains from June to September. A tree yields from one to four kerosene tins of oil, i.e. from four to sixteen gallons, trees yielding thin oil usually giving more than those yielding thick oil. Thick oil is considered to be superior to thin oil for the local uses to which the oil is put. Sometimes a tree is found which yields no oil at all. Tapping is done again on the same tree only after a lapse of about 10 years. The oil, which has been tested at the Imperial Institute in London, is sold locally for about three to four rupees per gallon for painting on doors, windows, rafters, pillars, and ceiling planks, a fresh coat being applied periodically. At one time the oil was said to be a substitute for copaiba balsam, but this was not confirmed by extensive trials in London, and neither the distilled oil nor the brittle resin obtained from this oleo-resin appear to have any great commercial possibilities, although they have been used medicinally and for soap- and varnish-making. There is no export of the oleo-resin, and the uses to which it is put are purely local. The tapping of the oil does, nevertheless, bring in a fairly considerable revenue in the forest divisions where it is practised, the right to tap being leased out to contractors for periods of two years at a time.

XVII

DRUGS, SPICES, EDIBLE PRODUCTS, AND POISONS

DRUGS

ROOT DRUGS; *Podophyllum emodi*—*Saussurea lappa*—*Aconitum* spp.—*Acorus calamus*—*Rheum emodi*—*Picrorhiza kurrooa*—*Valeriana wallichii*—*Asparagus adscendens*—*Urginea indica*—*Berberis aristata* and *B. lycium*. BARK DRUGS; quinine—*Cinnamomum tamala*—other drugs. FRUIT AND SEED DRUGS; *Strychnos nux-vomica*—*Aegle marmelos*—*Ricinus communis*—*Cassia fistula*—*Carum copticum*—other drugs. LEAF DRUGS; *Artemisia maritima*—*Ephedra gerardiana*—*Vitex peduncularis*—*Gaultheria fragrantissima*—*Melia indica*—*Cannabis sativa*.

SPICES AND EDIBLE PRODUCTS

Cardamoms—pepper—*Curcuma aromatica*—cinnamon—edible products.

POISONS

Bark poisons—root poisons—fruit and seed poisons.

A very large variety of drugs and spices and edible products are obtainable from forest trees and plants, and their numbers probably run into thousands. It is quite clear, therefore, that it is only possible to mention a few of the more important from an economic point of view.

DRUGS

India possesses a considerable number of drugs which are officinal in the *British Pharmacopœia* and which are, therefore, valuable commercially. In addition, there are countless drugs which find application in the indigenous systems of medicine and are well-known remedies amongst villagers and others. Comparatively few of these, however, have been made the subject of scientific study and amongst them there might well be some which might prove to be of great importance in both Eastern and Western medicine when they have been properly studied. As a case in point the various species of *Ephedra* may be mentioned. This crude drug has been known for thousands of years in Chinese medicine, but it is only of recent years that it has been studied chemically and the active principle isolated. As a result of this study the crude drug has been accepted as officinal in the *British Pharmacopœia* and the active principle, ephedrine, is now a valuable drug used in the treatment of asthma and hay fever,

and makes an excellent substitute for adrenaline. What is required is a chemical study to be made of these indigenous drugs, the active principles isolated and their physiological properties, if any, determined. This work will take time and will lead to many failures, but, if pursued, may give results that will be of great assistance to medicine in the continuous fight against disease.

Root Drugs

Podophyllum emodi

This is a small herbaceous plant with perennial roots, common in the temperate districts of the Himalayas, more especially in the Punjab, Jaunsar, and Kashmir. Formerly the demand for **Podophyllum emodi** roots was small, but there was a great demand for Indian *Podophyllum* during and immediately after the Great War when American supplies were cut off. Since then, it has been unable to compete with the latter even in Indian markets. The American species is **Podophyllum peltatum**. The drug is very plentiful and the total demand could be met from Kashmir alone. It is used in the preparation of medicines, its action being of a purgative nature similar to calomel.

Saussurea lappa

The roots of **Saussurea lappa**, a perennial herb, afford the costus root of commerce, more commonly known as *kuth*. This plant is now chiefly confined to Kashmir, and all *kuth* that finds its way to the plains' markets otherwise than from Kashmir is fairly certain to be smuggled *kuth* from Kashmir brought illicitly through Kulu, Chamba, Hazara and other frontier districts. The roots are collected in September and October, cut into pieces 3 to 4 inches long which are artificially dried in the forest, and then transported to the godowns at Baramula in Kashmir. The *kuth* is then sold and is transported to Calcutta and Bombay, from where it is exported. The drug was extensively used in India in former times, but at present the consumption is very limited. The bulk of the supply finds its way to China, where it is sold at very high prices. Its uses are somewhat obscure, but it is said to be used as an incense in pagodas, for placing in mandarin's coffins, and as a medicine. In Hindu medicine the *kuth* root is described as an aromatic and stimulant, and is said to be useful in cough, asthma, fever, dyspepsia, and skin diseases. Being strongly scented it is also used in perfumery and for keeping insects out of clothes. It is used a lot by merchants in Kashmir for protecting shawls from the ravages of insects. The drug has been tested for its pharmacological action and therapeutic properties at the Calcutta School of Tropical Medicine. The active principles were found to be (1) an essential oil, (2) a glucoside, and (3) an alkaloid. The oil was found to possess strong antiseptic and disinfectant properties, while the glucoside caused a small but persistent

rise of blood pressure. It was found that the powdered root and alcohol extract were expectorants and were beneficial in asthma, lessening the severity of attacks and reducing their frequency.

Aconitum spp.

There are in India about 24 species of aconites found scattered over the mountains of the Himalayan ranges and extending down into Burma. Some are virulent poisons whereas others are useful medicinal drugs. Many forms are used extensively throughout India, and few drugs are more frequently found in native medicines, or more generally understood by native drug-dealers, than the roots of *Aconitum*. They are not however exported, and the aconite of commerce is derived from **Aconitum napellus**, which does not occur in India. Mention may be made of **Aconitum heterophyllum**, known as *atees*. The root is officinal in the *Indian Pharmacopœia* and is considered astringent, stomachic, and aphrodisiac. It is a valuable febrifuge and antiperiodic and is used in place of quinine. It is considered to be an excellent tonic for combating debility after fevers and other diseases, and is very efficacious in diarrhœa and dysentery. The active principle is atisine, an amorphous alkaloid of intensely bitter taste but non-poisonous.

Acorus calamus

This semi-aquatic perennial is cultivated in damp marshy places in India and Burma and is often found as a weed of cultivation spreading apparently from walls dividing the fields. The rhizomes of the plant constitute the well-known *bach*, which is a simple useful remedy for flatulence, colic or dyspepsia, and a pleasant adjunct to tonic or purgative medicines.

Rheum emodi

This is a herb with a stout stem which is found in Nepal, Sikkim and Kashmir. The roots of this species constitute the large variety of Indian or Himalayan rhubarb. It is used as a purgative and astringent tonic, and deserves greater attention, as it is easily cultivated and there is a good demand for a substitute in India to take the place of Chinese rhubarb, an imported drug which is little, if at all, superior to Indian rhubarb.

Picrorhiza kurrooa

The roots of this herb, which has a perennial woody stock and which is common in the Alpine Himalayas from Kashmir to Sikkim, are valuable medicinally. It has been admitted to the Indian and Colonial Addendum of the *British Pharmacopœia*. The crude drug appears on the market in short dry

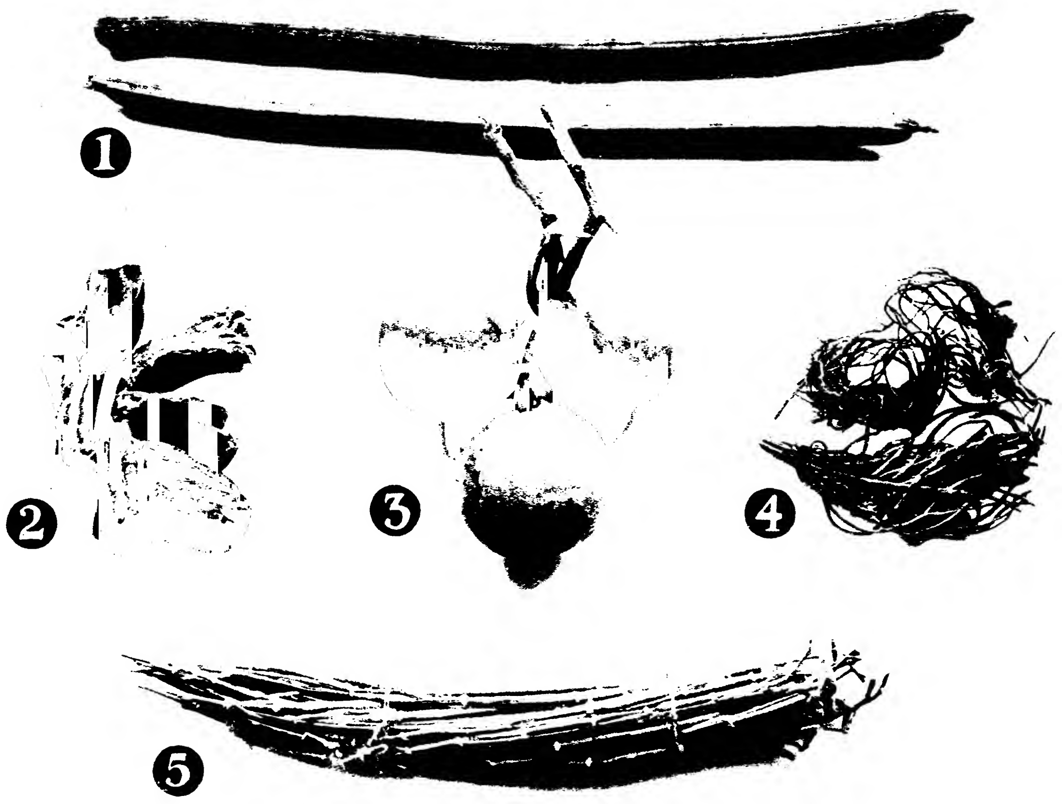


PLATE XV. Common Indian forest medicinal plants

1. *Cassia fistula* (*amaltas*) pods
2. *Saussurea lappa* (*kuth*) roots
3. *Aegle marmelos* (*bael*) fruits
4. *Podophyllum emodi* roots
5. *Holarrhena antidysenterica* pods

Facing p. 292.

pieces of root about 2 to 3 inches long. It is used as a stomachic, tonic, and as a febrifuge in cases of fever. The root contains a glucoside, picrorhizin, to which its medicinal value is due.

Valeriana wallichii

The roots of this perennial herb, found in the temperate Himalayas from Kashmir to Bhutan, resemble those of the officinal plant, *Valeriana officinalis*, except that the latter contains a high percentage of volatile oil. The root acts as a stimulant and antispasmodic, and its use is indicated in nervous and hysterical symptoms. The roots have been investigated by the Calcutta School of Tropical Medicine and the opinion was expressed that they would be an excellent substitute for the imported roots now used by druggists.

Asparagus adscendens

This sub-erect shrub occurs in the Western Himalayas, in the Punjab from Murree eastwards to Kumaon and in most sal (*Shorea robusta*) forests. Its roots constitute the *safed musli*, a valued tonic prized by all followers of the indigenous systems of medicine. It is said to be useful in diarrhœa, dysentery, and general debility.

Urginea indica (Indian squill)

This widely distributed herbaceous plant produces bulbs the size of a small orange. The bulbs are used as a substitute for the true squill (*Urginea scilla*), which is imported into India from the Mediterranean and is prescribed as an expectorant, digestive, diuretic, and deobstruent in many diseases, more especially in asthma, dropsy, rheumatism, leprosy, and skin diseases. The Indian squill is in no way inferior to the imported article, but is much cheaper, and as plentiful supplies are available from Chittagong and other places, it will no doubt replace completely the imported squill before very long. Squills are also used, in localities where they are common, for preparing a size for cloth.

Berberis aristata and B. lycium

From the root and lower stem wood of these two species a brown extract is prepared which is known as *rasaunt*. The roots and stems are cut up into small chips which are boiled in earthen pots with water, and the *rasaunt* is extracted in very much the same way that cutch is extracted from the heartwood of *Acacia catechu*. When prepared, *rasaunt* is of the consistency of thick treacle and is poured into receptacles made of leaves. Large quantities are used in Sind for mixing with drinking water. It is said to make the water cool. Another

important use is in the treatment of ophthalmia, the active principle being berberine. It is also used for piles and as a tonic and laxative.

BARK DRUGS

Quinine

By far the most important of all Indian drugs is the well-known quinine, yielded by the bark of various species of **Cinchona**, but as the *Cinchona* plantations of India are not under the management of the Forest Department they need not be further considered.

Cinnamomum tamala

Another important bark drug is that produced by **Cinnamomum tamala,** known commercially as cassia bark. The tree is of a moderate size, and extends along the sub-Himalayan tracts, becoming common in East Bengal, the Khasya Hills, and Burma. There are about 24 species of *Cinnamomum* in India, and barks from other species, more especially **Cinnamomum zeylanicum,** are very often confused with true cassia, whereas *Cinnamomum zeylanicum* really yields the true cinnamon spice bark. *Cassia* bark gets its fame from the perfumed oil it contains, which is extensively used in soap-making and medicine. The leaves of this species also yield an aromatic oil, and are used by themselves as a flavouring for food throughout India.

Other drugs

Other drugs under this heading are numerous, but the following may be noted as of special interest:—

Holarrhena antidysenterica.—The bark is used extensively throughout India for dysentery and fever.

Soymida febrifuga.—Produces a bark used for fevers and as a stimulant.

Alstonia scholaris.—A tall evergreen tree of the moister regions of India, yielding the *dita* bark of commerce, used as a remedy for chronic diarrhœa and dysentery and as a substitute for quinine.

FRUIT AND SEED DRUGS

Many forest fruits and seeds provide valuable medicinal drugs, but the majority are of local interest only and few are exported in any large quantity.

Strychnos nux-vomica

Perhaps the best known of the seed drugs is strychnine, the product of **Strychnos nux-vomica,** a moderate-sized deciduous tree found in Central and

South India, Bengal and Orissa, and especially common in the Gorakhpur forests and on the West Coast. The fruits are usually collected by contractors, and the seeds are washed out and dried in the sun. Sometimes the seeds are picked up from the ground, but they do not fetch such a good price as the seeds collected from the fruits. They are then sold to native dealers who dispose of them to export merchants and others. The 'buttons' (seeds) are then hand-sorted by the exporters and all impurities are removed before shipment. Floaters, i.e. light seeds which float in water, are packed separately. The drug is a powerful poison and is used all over the world as a stimulant in tonics. The buttons actually contain two alkaloids, strychnine and brucine. The former is the valuable alkaloid and it is separated from the brucine during manufacture. The exports to Europe and America are considerable, the chief ports of dispatch being Madras and Bombay. **Strychnos nux-blanda**, a Burmese species, produces fruits and seeds which are very similar to *Strychnos nux-vomica*, but the seeds contain no strychnine.

Aegle marmelos

Another well-known fruit is that of **Aegle marmelos,** the *bael* tree. The tree is found wild and cultivated throughout India and Burma, and the fruit is used for many purposes. As a tonic and astringent in cases of dysentery and diarrhœa it is well known, and is frequently referred to by ancient Sanskrit writers as having proved effective when all other remedies had failed. *Bael* fruit is also used as a food by the poorer classes and is popular, both among Europeans and Indians, when made into a refreshing drink. The mucous substance secreted round the seeds is used extensively as a cement, and is also employed as a varnish and even as a substitute for soap for washing clothes.

Ricinus communis

The uses of castor oil, yielded by the seeds of **Ricinus communis**, are too well known to require further description. The plant is nowadays mostly found cultivated with other field crops, but being a hardy species it is no uncommon thing to find fairly large quantities of the castor-oil plant scattered throughout the forests of the sub-Himalayan areas, and the seeds of these plants are often collected by the villagers.

Cassia fistula

The pulp of the long pods of **Cassia fistula** (rajbrikh), the Indian laburnum or *amaltas*, is used throughout India as a purgative. It is one of the commonest domestic medicines of India, and owing to its well-known properties the drug is often known in the trade as the purging fistula.

Carum copticum

The seeds of this plant, known as *ajowan*, yield the well-known thymol of commerce, an antiseptic of proved value used in the treatment of hookworm disease and as a constituent of tooth-pastes and mouth-washes. The seeds themselves are used as an antispasmodic and stimulant, and are said to have tonic and carminative properties. The plant is common in Bengal, Central India (Indore), and Hyderabad. In the last-named State it is cultivated, and over 8,000 acres are planted with it. It is also cultivated in the Punjab and United Provinces.

Other drugs

Amongst other fruit and seed drugs may be mentioned **Caesalpinia bonducella**, yielding the fever-nut used extensively in India in cases of intermittent fever, and **Tamarindus indica**, which yields a well-known laxative drug employed in native medicines since the earliest periods. There is a large local trade in the acid pulp of the fruit of this tree in South India, where it is used in cooking. While mentioning this tree, it is interesting to note that the leaves are said to exhale an acid at night, and Gamble states that the cloth of tents pitched under a tamarind tree is quickly decomposed if the leaves fall on to the tent and are allowed to remain on it for a day or two.

LEAF DRUGS

There are a few drugs obtained from the leaves of forest trees and plants which are extensively used in medicine, and some of these are of considerable medicinal value.

Artemisia maritima

The leaves and flowering tops of this shrub yield santonin, a very valuable vermifuge. The main source of supply of this drug is Russian Turkestan, whence the world's markets have previously been fed. Of late years a variety, namely **Artemisia maritima, var. stechmanniana**, has been exported to Europe from the Kurrum Valley in the North-West Frontier Province, and a factory has also been set up in Kashmir for the production of santonin from the plants found there. Santonin is a very expensive drug, as the yield is small and supplies limited, so that the newly discovered sources of supply in India will enable the country to produce santonin in larger quantities and at a cheaper rate than was formerly the case. An investigation regarding the seasonal variation in the percentage of santonin in a plant has shown that such a variation exists, and that the plant should be collected in August if the best yield is wanted. Santonin is a drug which is of great importance to India, as a survey has shown that over 65 per cent

of the population of Burma, Assam, Orissa, and Madras where the rainfall is heavy are affected with *Ascaris* and *Oxyuris* infections.

Ephedra gerardiana

Ephedra gerardiana, found in dry stony places and on rocks in the Himalayas of North India, has come into prominence of late years, due primarily to its possessing an alkaloid (ephedrine) which has been discovered to possess important properties for the treatment of asthma and hay-fever, and to its use as a substitute generally for adrenaline. The demand for ephedrine has greatly increased during the last few years, and interest is now being taken in supplies from India. Former supplies came chiefly from China. The Indian plant has been closely studied by the Forest Research Institute at Dehra Dun and it has been found that it contains enough ephedrine to make it commercially valuable if the plant is collected at the right time of the year, but that there is a seasonal variation in the alkaloid content. The dried plant is now being exported from India on a small scale.

There are several other species of *Ephedra*, and their distribution in India is wide, but it is chiefly those species growing in the north-west of India which have a high alkaloid content. It is also interesting to note that ephedrine has been found in small quantities in *Sida cordifolia*, a plant found in the plains of India. A similar alkaloid has also been discovered in *Moringa pterygosperma* but it is not known whether this is true ephedrine or not.

Vitex peduncularis

A drug is obtained by infusion from the leaves of **Vitex peduncularis**, a fairly common large tree of the northern slopes of mixed forests throughout India and Burma. The leaves are collected and dried, and the drug extracted by soaking them in boiling water. At one time it was thought that this drug would prove to be a real cure for black-water fever, but of late reports have not been so promising. Black-water fever is now treated with an extract from *Cassia* bark.

Gaultheria fragrantissima

The leaves of **Gaultheria fragrantissima** yield on distillation the commercial product known as wintergreen oil, used in flavouring medicines and aerated waters and for rubbing into the body in cases of rheumatism. Salicylic acid is also obtained from wintergreen oil and the well-known aspirin of commerce is a derivative of it. The trade in this product has not, however, developed to any great extent as aspirin is made more cheaply synthetically. The trade in wintergreen oil is however brisk.

Melia indica syn. Melia azadirachta

Another well-known leaf of popular use is the neem leaf, obtained from **Melia indica**. Neem leaves contain an onion-smelling compound which is objectionable to insects, and they are, therefore, extensively employed to preserve books, papers, and clothes, from the ravages of moths and termites. Powdered neem leaves when burnt are said to prove fatal to all insects. Neem oil, a common commodity of Indian bazaars used as an antiseptic and for burning purposes, is obtained from the seeds of this tree.

Hemp

The hemp plant, **Cannabis sativa**, grows wild throughout the Himalayas and foothills, from Kashmir to East Assam. It is also cultivated in a small way in India. It is not an important forest product, but is a very well-known one, as being the source of the narcotics *ganja*, *charas*, and *bhang*.

Ganja is produced from the dried flowering tops of the plant, and is used for smoking and taking internally. *Charas* is a resinous substance exuded from the flowering tops and leaves. It contains the active principle cannabinol which is the basis of the narcotic hashish.

Bhang is the name usually given to a drink made out of pounded *ganja*, in fact the two names are often used indiscriminately for both the powdered flower tops and the drink.

Before leaving this section, the uses of camphor, obtained from the leaves of **Cinnamomum camphora**, must not be overlooked. This product has been fully described in Chapter XIII, p. 252.

SPICES AND EDIBLE PRODUCTS

Spices are closely connected with drugs, and it is often difficult to separate the two as most spices are also used for medicinal purposes, but in this section the more important products employed as flavouring agents will be described.

Cardamoms

A very important article of trade, and one yielding considerable revenue to the Forest Department, is the well-known cardamom of commerce. There are two species of plants yielding cardamoms, the more important of which is **Elettaria cardamomum**, the true cardamom, whose fruits are known as the Malabar cardamom or lesser cardamom. The other species is **Amomum subulatum**, a native of Nepal, yielding the Nepal cardamom or greater cardamom of commerce.

The true cardamom is a perennial herb, indigenous in South and West India, and Burma. It is found growing wild in many districts, more especially in Kanara and Malabar in Madras, and in the Tenasserim district of Burma. It is also extensively cultivated in spice gardens and fruit orchards. The fruits

are borne on long flower spikes which shoot out from the base of the plant and very often creep along the surface of the ground. In forests where the plant is plentiful the brushwood is sometimes cut down and the ground cleared for the better growth of the plants. The ripe fruit-clusters are collected in October and November, and are dried in the sun for 3 or 4 days, although artificial drying is sometimes employed. Sun-dried cardamoms are, however, considered the best and are known as green cardamoms, but other qualities are often dried and bleached according to the market they are intended for. In India, three classes of cardamoms are usually found in the market, the green cardamom used from end to end of India for eating with *pan*, a small white cardamom used for the same purpose, and a hard brown cardamom used extensively as a flavouring spice in curries and savoury stews. The demand from other countries is very large, and the export trade in cardamoms amounts to several lakhs of rupees every year.

Pepper

Various species of pepper plants are found in the forests of India, the commonest being **Piper longum**, found in the damp evergreen forests of Bengal, Assam, and the West Coast. The fruits are gathered before they are ripe, in January, and are dried in the sun before marketing. The common *gol mirch* is the fruit of **Piper nigrum** found in the forests on the west coast of Madras, and large quantities are used in India and also exported to foreign countries. It is also largely cultivated in Malabar.

Curcuma aromatica

The roots of **Curcuma aromatica**, a common forest plant of Bengal and South India, are known as wild turmeric and are extensively used throughout India as a substitute for true turmeric (*Curcuma longa*), a cultivated plant, which is an indispensable ingredient in curries and used also for colouring food-stuffs. **Curcuma angustifolia** roots are known commercially as East Indian arrowroot, and are used all over India as a substitute for true arrowroot (*Maranta arundinacea*) for medicinal purposes and also as a food. It is a native of the central tracts of India from Bengal to Bombay and Madras and there is considerable trade in it in the Central Provinces and in Malabar.

Cinnamon

The bark of the cinnamon tree, **Cinnamomum zeylanicum**, is too well known as an aromatic spice to require description. The tree is a native of West and South India, and is often found cultivated as an ornamental bush.

Edible products

Under the title of edible forest products it would be quite possible to fill a large book, but the more common edible fruits of forest trees are so well known

that it is not intended to waste valuable time over them. They are not as a rule revenue-producing products, but are extensively used by villagers and others living near the forest as supplementary to their ordinary diet. The more common and best-known forest fruits are the mango (**Mangifera indica**), the jack-fruit (**Artocarpus integrifolia**), *jaman* (**Eugenia jambolana**), walnut (**Juglans regia**), the hog-plum (**Spondias mangifera**), the *bher* fruit (**Zizyphus jujuba**), the mangosteen (**Garcinia mangostana**), and the wild cherries, pears, and figs. Many seeds and nut kernels are also used as food. For example the edible seed of *Pinus gerardiana*, known as *chilgoza*, is an important article of trade throughout India. The young shoots of bamboos are considered a delicacy in curries, and the palms provide many edible products such as coconuts, dates, sago, and *gur*. Finally there are the edible mushrooms of which there are a large variety in India. The best known of these is perhaps **Morchella esculenta**, the morel, which is collected in April in Kashmir and other Himalayan districts, dried in the sun on long strings and exported to European countries.

POISONS

Many forest plants yield poisons of varying importance. Some are of real economic value for medicinal purposes, such as strychnine and aconite already described under Drugs, while others are used extensively as fish-poisons and even for more criminal purposes such as the poisoning of cattle by hide-contractors.

It is not intended to give a lengthy description of these poisons in this Manual, but a knowledge of the origin of some of them will often be useful to a Range Officer.

Bark poisons

Amongst bark poisons may be mentioned those obtained from the barks of **Ougeinia dalbergioides**, **Berberis aristata**, **Albizzia procera**, **Barringtonia acutangula**, and **Myrica nagi**.

Root poisons

Amongst root poisons the best known are those of **Euphorbia tirucalli** and **Millettia pachycarpa**, both used for poisoning fish and birds.

Fruit and seed poisons

Fruit and seed poisons are very numerous. The small red seeds of **Abrus precatorius**, well known in India as goldsmith's weights, and used also as beads for necklaces, contain a violent poison, and the resin exuded from the bark of **Antiaris toxicaria**, a large evergreen tree of Burma and the Western Ghats, is used as a poison for tipping arrows to kill game.

XVIII

ANIMAL, MINERAL, AND MISCELLANEOUS PRODUCTS

ANIMAL PRODUCTS; honey and wax—silk—horns and skins—ivory—hunting, fishing, and elephant-catching—bats' guano—edible birdnests—bees' dammar. MINERAL PRODUCTS. MISCELLANEOUS PRODUCTS; leaves—soap-nuts—marking nuts—sola pith—bead seeds.

ANIMAL PRODUCTS

Under this heading comes the most important, from a forest-revenue point of view, of all minor forest products, namely lac, the produce of the small insect **Laccifer lacca**. This valuable product is dealt with in detail in Chapter XIX.

Honey and wax

A profitable source of revenue is provided by wild bees, the two largest being **Apis dorsata** and **Apis indica**. The right of collection of honey and wax is usually leased to contractors, who collect the honey for sale in the local markets and melt the wax for making candles and sealing-wax. In some districts, as for example in the Sunderbans of Bengal, the collection of honey is under special management plans mentioned in the Working Plan, and sanctuaries are provided for the preservation of the bees. In the case of dangerous bees, the collector covers himself with a fine net or blanket, and drives the bees away with a lighted torch. The comb is then cut off and lowered to the ground by a rope. In the case of less dangerous bees, a good shaking of the branch or tree on which the nest is situated will be sufficient to drive them off. Two crops of honey are obtained from *Apis dorsata*, one at the beginning, and the other at the end of the rains, the first crop producing the best honey. The honey is usually separated from the comb by slicing off the tops of the cells with a long sharp knife and allowing the honey to run out through a fine sieve or squeezing it through muslin. The pure beeswax is obtained by placing the comb from which honey has been removed in boiling water, when the wax melts and floats to the surface, from which it can be skimmed off. India exports large quantities of beeswax to foreign countries.

A point worth remembering about the collection of honey is that such collection generally takes place in the dry hot season, and collectors use smoke from fires built underneath the trees to drive away the bees. This often results

in forest fires starting, and some serious fires have been reported as having been caused by this means.

Silk

There are many kinds of silk-worms, both wild and domesticated. The best known are those which are reared on mulberry trees (*Morus indica* or *Morus alba*). Other silk-worms are essentially forest insects, and are found wild on *Bombax malabaricum*, *Eugenia jambolana*, *Ficus* spp., *Terminalia tomentosa* and other trees. The best known of these insects is **Antheraea paphia**, producing the famous tussur silk of commerce.

Semi-domestication of silk-moth caterpillars is practised in some districts. Cocoons are collected in the forests and placed on trees in plantations or gardens where they can be better looked after. Small boys are employed to protect the insects from the ravages of birds, and the results of this practice are good. In the case of tussur, two to three crops of cocoons are usually obtained each year and about 1 tola of tussur silk can be got from 15–20 cocoons. Some races of tussur are however only one-brooded.

Horns and skins

Another source of forest revenue is from the sale of horns and skins of wild animals, more especially deer. Sambhur and chital horns find a ready market, for use in glue manufacture, and for making knife handles, buttons, and other articles. Rhinoceros horns are used as a valuable medicine in China, and are worth their weight in gold.

Ivory

Most of the world's supply of ivory comes from Africa, and the revenue from ivory in India is comparatively small being chiefly confined to confiscated ivory and tusks found in the forests.

Hunting, fishing, and elephant-catching

A certain amount of revenue is collected annually in India on account of the sale of permits to hunt and fish in Reserved Forests, but as large rewards are paid out annually for the destruction of man-eating tigers and leopards, rogue-elephants, wild dogs, wolves, etc., the net profit does not amount to much. The control of shooting, hunting, and fishing is, however, in the hands of the Divisional Forest Officer in most provinces, and his responsibilities in this connexion are by no means small.

In all provinces in India there is now a closed period every year, during which no animal or bird may be shot in Reserved Forests. In addition, some provinces

also close shooting blocks for the first half of every month of the open period, and some go even further and have sanctuaries, in which no animal or bird of any description may be killed, except under special licence. Such sanctuaries are usually under the supervision of a Game Warden who is more often than not a forest officer.

Forest shooting rules vary in different provinces, but the general idea is to limit the amount of game to be killed, and to prevent the slaughter of immature animals and females. This is done by issuing shooting licences which prescribe exactly the number of each kind of game which may be shot. The trapping and poisoning of game is strictly prohibited in most forest areas. On the whole, the shooting rules of India are adequate, but in some districts the fauna is on the decrease, due very largely to the great number of gun licences now issued to irresponsible persons, and to heavy poaching by villagers living in or near Reserved Forests.

Protection of crops is also responsible for the slaughter of a large number of innocent animals, but it is hard to put a stop to this kind of thing as the actual killing of the animals is usually done outside Reserve boundaries, and the plea that the animal was damaging crops is usually sufficient to give the most hardened poacher immunity from official attention.

Fishing also has its protection rules in many forest districts, and there are now several Fishing Associations in India whose object is to protect forest waters from poaching and to provide sport to their members. In addition, there is sometimes official protection of forest streams, which are spawning-grounds of fish which are an important source of food to people living on the main rivers below, but fishing from a forest point of view is not in the same category of importance as shooting, and the revenue derived therefrom is negligible. The Forest Department has, however, had much to do in connexion with fish hatcheries in the Punjab, United Provinces, and Madras, and these hatcheries have proved invaluable for stocking rivers with fish. The Department has also been responsible for obtaining legislation to prevent rivers being blocked by *bunds*. These *bunds* prevent fish from going up the rivers to their spawning-grounds, and where such *bunds* are necessary for irrigation purposes, a channel should always be left clear on one side of the river, so that fish going up to their spawning-grounds are not checked.

Elephant-catching is carried out in Eastern Bengal, Assam, Madras, and Burma, and permits to catch elephants are given out to trustworthy agents who pay a percentage to Government on the number of elephants captured. Many of the elephants thus caught are sold to Government for work in the forests.

The method of capture varies in different provinces, but usually consists in driving the elephants into enclosures, known as *kheddahs*, or digging pits in the

vicinity of wild elephants' haunts, into which the animals fall and from which they are later extracted by the aid of trained elephants. Other methods of capture are noosing young elephants from the backs of trained tame elephants, or tying the legs of the wild animals under the cover of female decoys, but neither of these methods is used so extensively as the first two, which in some districts produce considerable revenue to Government.

Bats' guano

The right to collect bats' guano is usually sold by auction every third year. It is found in caves, chiefly in Madras and Burma. Guano is used in the manufacture of saltpetre and as a manure, and produces large revenue to Government in the localities where it is found.

Edible birdnests

Edible birdnests are composed of a gelatinous substance formed by the salivary glands of two species of swift (*Collocalia francica* and *Collocalia innominata*). These birds nest in the rocks of the Nicobar and Andaman Islands, and in three groups of caves on the Burma coast. The right of collection of the nests is sold by auction; the revenue in some years being considerable. One of the Burma groups was sold for Rs20,000 some years ago, but the nests seem to be diminishing in numbers of late. The chief market for edible nests is China, where they are considered a great delicacy, the best quality white nests selling for as much as As.10 each.

Bees' dammar

A dark resinous substance, not unlike wax, is made by a small stingless bee of the genus *Melipona*. This is collected, more especially in Burma, and is known as *pwenyet* or bees' dammar. It is much prized by the Burmese for caulking boats.

MINERAL PRODUCTS

Among the mineral products found in forests may be mentioned building-stones, road-metal, mica, limestone and other similar materials.

Mica is worked on a large scale in the Reserved Forests of Bengal, Bihar, Orissa, and Madras, and manganese in the Panch Mahals of Bombay and to a lesser extent in Central India and Madras. The direct revenue from minerals is, however, small, but mines are usually large consumers of timber for pit-props and fuel, and in some cases, such as the large silver and lead mines in Upper Burma, a whole Subdivision is set aside and worked entirely for the production of timber for the mines.

The collection of mineral products from forest areas may be done in four ways.

(1) By mining, i.e. sinking a shaft below the ground surface and excavating the minerals from underground.
(2) By quarrying, i.e. excavating on the surface of the ground from pits or quarries.
(3) By collection from the surface of ground covered with tree growth.
(4) By collection from river-beds and other open spaces. Limestone brought down the rivers by floods is often collected in this way.

In the case of (1), a good deal of debris is thrown up at the entrance of the mine shaft, but the damage to forests is usually slight. In the case of (2), considerable damage may result on account of hillsides becoming exposed and liable to landslides, and to stones and rocks rolling down the hillside and damaging young forest crops.

Damage may also be severe in the case of (3), due to carts and pack-animals being driven at random over large areas and crushing young growth. In addition, carts can do a lot of harm to larger trees by bumping against them and either breaking them or damaging the bark.

Collection from the beds of streams and open spaces is usually harmless.

The leases for the collection of minerals are usually on a fixed payment or royalty basis.

Miscellaneous Products

There are several other minor forest products which do not fall under any of the classes already described. Among these, the following may be mentioned.

Leaves

Leaves are used throughout India for many purposes, of which thatching is perhaps the most important.

Thatching leaves include those of **Tectona grandis**, **Bauhinia vahlii**, **Butea frondosa**, and **Dillenia pentagyna**. Palm leaves are also extensively used for thatching, the best-known being **Nipa fruticans**, **Licuala peltata**, and **Livistona jenkinsiana**. In the Sunderbans forests of Bengal the leaves of *Nipa fruticans*, known locally as *golpatta*, are sold in very large quantities running into thousands of tons per annum. Thatching is the chief use to which the leaves are put, but they are used also for making floats for logs and fishing. From a revenue point of view these leaves are, therefore, a very valuable forest product. Other large leaves are used for making umbrellas, cups, and plates, the commonest being **Bauhinia vahlii**, **Butea frondosa**, and **Tectona grandis**. Cheroot and

cigarette wrappers are often made out of leaves other than tobacco leaves. Burma cheroots, for instance, are usually wrapped in the leaves of **Cordia myxa** and **Careya arborea**, while in Bombay **Diospyros melanoxylon** and **Bauhinia racemosa** are extensively used as *bidi* wrappers.

Soap-nuts

The *ritha* nut or soap-nut is obtained from a large tree, **Sapindus emarginatus**, found wild and cultivated in Madras and Bombay, and from **Sapindus mukorossi syn. detergens** in North India. The nut is utilized as a substitute for soap, and is used universally by natives of India for washing purposes. Another well-known soap substitute is the pod of **Acacia concinna**, a climbing shrub, found in most parts of India and Burma. These pods are often confused with the soap-nut, and the vernacular name of *ritha* is often applied to them, whereas their true vernacular name is *shigakai*. They are extensively used for washing silks and woollen goods, and like soap-nuts are very popular for washing the hair. *Shigakai* is also very good for cleaning old and dirty brassware, and, if powdered and boiled, adds a fine gloss to silk and gives it a faint buff tinge.

Marking nuts

The fruits of **Semecarpus anacardium**, a deciduous tree of the sub-Himalayan tracts, are collected in large quantities and are known as marking nuts. The pericarp contains a powerful and bitter astringent juice which is used as a marking-ink.

Sola pith

The pith used in the manufacture of sola topees is obtained from the stems of two aquatic plants, **Aeschynomene aspera** and **Aeschynomene indica**, which are found in and around lakes and tanks, chiefly in Bengal, but also in Assam, Burma, and South India.

Bead seeds

Many kinds of seeds are used as beads for making up into necklaces. Among the best known are the small scarlet seeds of **Abrus precatorius**, known as *rati*. The seeds have already been mentioned under Poisons, and they are also well known in India as jewellers' and goldsmiths' weights. Another decorative seed is that of the grass **Coix lachryma-jobi** or Job's tears. These seeds resemble beads very closely and are used for necklaces and rosaries and for decorating the dresses of hill tribes. The seeds of the talipot palm, **Corypha umbraculifera**, resemble, and are very nearly as hard as, real ivory, and are extensively employed as beads and are often stained and sold as coral. They are exported to Europe

in fair quantities, chiefly to be made up into buttons. In some years there are very large quantities, running into hundreds of tons, of these seeds available for sale, and but for the fact that they discolour with age they would compete very favourably with true ivory for small articles.

Other seeds used for beads and necklaces include those of **Adenanthera pavonina**, which are bright scarlet seeds rather larger than *Abrus* seeds, and also used as jewellers' weights; the nuts of **Putranjiva roxburghii**, worn as rosaries to avert the evil eye, and the hard nuts of **Elaeocarpus ganitrus**, which are polished and stained and then made into rosaries and bracelets, much prized by Brahmins and *sanyasis* and sold in large numbers at all the big fairs, such as those at Allahabad, Benares, and Hardwar.

Part IV

IMPORTANT MINOR FOREST PRODUCTS INDUSTRIES

XIX

LAC AND THE MANUFACTURE OF SHELLAC

LAC; the lac insect—lac—lac dye—shellac—life history of the lac insect—larval settlement—infection—the lac crops—host trees—pruning—systematic cultivation of lac—distribution of lac—collection and storage. SHELLAC; manufacture—properties—uses.

By far the most important of all minor forest products from a revenue point of view is the resinous substance known as lac, which produces shellac, a product which is used all over the world for divers purposes. Its value is attached not only to India but to the world in general, as India virtually holds a monopoly in the production of shellac, and if the Indian supply failed the world's supply would fail with it.

LAC

The lac insect

Lac is a complex resinous substance excreted by a minute insect called *Laccifer lacca* belonging to the group of *Coccidae* or scale insects. Several varieties of the lac insect have been identified, but for the purpose of this note they may be considered as one.

Lac

In the case of the lac insect the scale, which is characteristic of the *Coccidae* group, consists of a resinous amber-coloured secretion together with the cast skins (*exuviae*) of the insects. This secretion is the crude lac, the raw material from which shellac is manufactured.

Lac dye

Lac dye, consisting of at least two dye-stuffs, is almost entirely concentrated in the body of the insects and in its eggs or young. It is a crimson dye which in former years was in universal demand, and the name still lingers in the well-known crimson lake. Since the introduction of aniline dyes, however, the lac-dye industry has steadily decreased and is now practically dead. This lac dye used to be recovered from the water in which the lac was washed prior to being made into shellac. The water was run into vats, where the dye was made to settle

by the addition of lime. Nowadays the dye water is more usually allowed to run to waste or is removed by cultivators free of charge for use as a manure.

Shellac

Fortunately, at the same time that the demand for lac dye decreased, the demand for the other product of lac, namely shellac, increased, and it now surpasses in value all other minor forest products. In 1929-30, 668,914 cwt. of lac and shellac valued at nearly Rs7,00,00,000 was exported from India. Of recent years, however, the price obtained for shellac has declined considerably, and in addition shellac now has to meet increasing competition from synthetic compounds. The more extended use of cellulose finishes has also caused a diminution in the demand for shellac for the manufacture of varnishes, but enormous quantities are still used in the moulding and gramophone-record industries, these two industries accounting for more than 50 per cent of the shellac exported from India. These industries are at present flourishing, and there is still a steady demand for shellac for these purposes.

Life history of the lac insect

The lac insect starts its life as a minute red-coloured creature called the larva. These larvæ are active and are capable of crawling a considerable distance, and are introduced on a suitable host tree by a process called infection, which will be referred to later. They crawl over the branches of the host tree until they find a suitable place to come to rest, usually on the underside of soft succulent twigs, and here they settle down. They then force their long slender proboscides through the thin bark and proceed to suck the juices of the tree. Once they have settled down they never move again but continue to suck the juices of the tree and grow. After a short time, a thin shining substance can be seen on the backs of the larvæ. This is the first appearance of the secretion known as lac. The original layer is then added to and thickened from the inside as more and more lac is secreted during the growth of the larva. The lac provides a protective covering to the insects, which are soft-bodied and, being now unable to move, would otherwise be an easy prey to predacious enemies such as birds and insects.

Larval settlement

When the larvæ settle down they do so in very large numbers and often completely cover the lower surfaces of the twigs, sometimes extending to the upper surfaces as well. When they start to secrete lac the secretion from one larva meets with and coalesces with that of its neighbour, and in this way a continuous or semi-continuous coat of lac is formed, at first slowly and later

more rapidly, over all the larvæ. During this period the larvæ are growing and undergoing changes. They are actually of two kinds, male and female, though they look alike to the naked eye. There is usually a preponderance of females, though cases are not unknown in which broods have contained a preponderance of males.

As growth proceeds, the secretion of lac continues, so that round each larva is produced a cell or test of lac, that round the male being thin and cigar-shaped, that round the female thicker and usually oval. This coating over the lac insect is called the encrustation, and each cell or test is provided with three openings to the outside, which are kept open by long, wavy, white filaments. The presence of these filaments is an indication that the lac insects are healthy, and in some cases are so numerous that the encrustation has a woolly appearance. Two of these holes (brachial pores) are for breathing purposes, while the third is the anal cleft, through which a sticky substance, known as honey-dew, is excreted. This honey-dew, which is excreted fairly freely, drops down on to and spreads over the surfaces of the leaves of the host. A black fungus grows on this honey-dew and gives a black appearance to the surface of the leaves and twigs of the host and is characteristic of a tree infected with lac.

The next event of importance is the emergence of the males. They grow to maturity under their protective covering of lac and then emerge by pushing open the operculum or opening situated at one end of the testa. These male insects are red in colour, have legs and antennæ and may or may not have wings. After emergence they crawl over the encrustation and fertilize the females, each male being capable of fertilizing several. They have then performed their function in life and die.

This period of fertilization is a most critical one in the life of the insects, as the males are delicate creatures, which easily succumb to heavy rain and the attacks of other insects and birds, and the females will not produce a full crop unless they have been fertilized.

After fertilization the females begin to secrete lac at a much greater rate and become less insect-like in their cells. Finally they become sack-like bodies in their protective covering of lac, while they still suck the plant juices through their proboscides.

The eggs now begin to ripen in their bodies and cracks appear in the encrustation, while an orange-yellow spot can be noticed in the cells. The eggs, when ripe, are expelled by the insect into the incubating chamber of the test, in which the new brood hatch out. After hatching they crawl out and start to look for places to settle down, thereby restarting the life cycle. All the eggs are not laid at once and the process for any given brood usually lasts from 3 to 4 weeks. This emergence from the female cell is known as swarming. The period

of swarming is also a critical stage, as at this time the insects are not protected by an encrustation of lac and are, therefore, subject to attack by predators of various kinds, while they are also exposed to the vagaries of the climate.

Even when the insect is enclosed in its cell it is not free from danger from insect pests, and it is estimated that an average of 60 per cent of the potential crop of lac is destroyed annually by insects. There are two main groups of these insect enemies, the predators and the parasites. Predators lay their eggs near the encrustation, and the larvæ which hatch out feed on the lac insects and may even eat their way into the encrustation until they are entirely concealed inside. The two most important of these are species of *Eublemma* and *Holococera*, the former being the most severe pest owing to its wide distribution. Parasites are very small insects which lay their eggs inside the lac cell, and their larvæ live on the surface of the lac insect or actually inside it.

Infection

Infection consists in introducing lac insects on to a new host tree, which has previously been pruned to provide a sufficiency of young succulent shoots on which the new larvæ can feed. Several days to a week before the larvæ are due to emerge from the mature female cells, branches bearing thick healthy encrustations are selected and cut into convenient lengths of 6 to 12 inches. These sticks are known as brood lac, as they contain the young swarm which is to give the future brood, and are used to convey the larvæ over long distances, even from province to province.

It is possible to forecast the date on which lac insects will swarm by the appearance of the encrustation and the presence or absence of the orange-yellow spot mentioned above. Swarming usually occurs 3 to 4 days after the spot has reached the anal opening, and this is the best time to start cutting the brood lac sticks where large areas have to be dealt with. Where areas are small, some cultivators do not cut the crop until emergence has actually begun. It is essential, however, that the brood lac should not be cut too soon before swarming. The female lac cells are alive when swarming takes place, and it is now known that they can to some extent control the swarming by delaying it if climatic conditions are inimical to the larvæ. Premature cutting deprives the female of the food supplies obtained from the host tree, thereby weakening her and destroying her power to control the swarming, while the young larvæ are also weakened, as they also through the mother are cut off from their food supply.

The brood lac should always be carefully examined after cutting, and all pest-infected sticks should be rejected, and only healthy lac-bearing branches should be used. The selected sticks are then tied with string, a piece of string

about 6 inches to 1 foot being tied at both ends of each stick so that two free ends of string are left at each end of the stick.

The actual inoculation can be carried out in three different ways, namely by (1) the longitudinal method, (2) the lateral method, or (3) the interlaced method.

(1) The **longitudinal** method consists in tying the sticks of brood lac so that they lie along the branches to be infected, touching them and fastened to them at each end by the strings. They should be tied at the base of the branches on the lower side so that the larvæ on emergence walk directly on to the fresh shoots. A bundle of brood lac sticks can be used instead of a single stick, the number of sticks in the bundle depending on the number of shoots originating from the branch beyond the point at which the bundle is tied. This is the method most commonly adopted and is said to give the best results.

(2) The **lateral** method consists in tying the stick across the gaps between new shoots so that each end touches a branch. This method is not to be recommended as wind may jerk the branches apart with the result that the two ends may no longer touch the branches and the brood lac stick may be left hanging from one branch only by its string. If this happened the larvæ would have to pass to the new host by the string bridge which might not be easy, particularly in a wind.

(3) The **interlaced** method is used when the new shoots from pruning arise in a close group from the mother branch, which commonly happens in the case of *Acacia catechu* (cutch) and *Ficus* spp. In this case the brood lac sticks are interlaced between the shoots at the point of origin and are tied with string. This method is useful where labour is scarce, and can conveniently be used in conjunction with the longitudinal method.

After all the good sticks have been tied in position, it will usually be found that a lot of short pieces of stick remain which are too small to be tied and also a number of small pieces of lac containing larvæ. They should not be wasted, but can be put loose into roughly made small wire-gauze or bamboo baskets, which can be used in place of sticks or can be tied to branches from which a number of new shoots have arisen.

It is essential that the right amount of brood lac be used to inoculate the host trees on the area to be dealt with. Under-inoculation leads to waste of space on suitable twigs, while over-inoculation leads to waste of brood lac and also causes mortality among the larvæ due to overcrowding on the young twigs, thus forcing the larvæ to settle on the thick mature branches where they only die. The correct amount to be used can only be learnt by practical experience.

If the brood lac has been collected at the right time, swarming should take place within a few days of tying on the brood lac sticks. The date on which the larvæ start swarming should be noted and the brood lac should be removed from

the trees 3 weeks from this date. If the correct amount of brood lac has been used the trees will then be fully inoculated. The reason for removing the brood lac is that the majority of the larvæ have emerged at the end of the three weeks period, while a number of the enemies of lac have not. During inoculation the trees should be inspected periodically and the brood lac removed as soon as it is seen that the available shoots are covered with sufficient larvæ. The brood lac can then be moved to other trees and used to inoculate them or can be transferred to trees which are under-inoculated. It must, however, be removed 3 weeks from the start of swarming, not 3 weeks from the date on which it was transferred to another tree.

In large areas, where labour is scarce, cruder methods of inoculation are often resorted to. These generally consist in interlacing the brood sticks between the new shoots without tying them, and in the more extended use of bundles of brood sticks and the tying of the brood sticks once only in the middle.

The methods described above are artificial methods of inoculating lac on to a new host tree. Another method of inoculation, known as natural infection, is used for propagating lac on a host which already bears a crop. This is done by leaving the mature lac to swarm on to the young branches of the same tree.

The lac crops

A life cycle or generation is the term applied to the time which elapses from the emergence of the newly formed lac larvæ to the fully grown female cells containing fresh larvæ ready to swarm. There are usually two life cycles in every district in which lac is grown, except in the case of lac grown on *Shorea talura* in Mysore, when there are three cycles in thirteen months.

The periods of different lac crops are controlled by the climatic conditions of the district in question, and the various lac crops are given different names as follows:—

Katki.—When inoculation takes place in June-July, the females are ready to give a swarm in October-November. This is called the *katki* or *rangeen* crop.

Baisaki.—The larvæ from the brood lac of the *katki* crop settle down on the host trees in October-November and the females are fully developed and ready to give another swarm in June-July. This is known as the *baisaki* crop, and brood from this crop is used to infect trees for the next *katki* crop and so on.

Kusmi.—A somewhat different cycle occurs when lac is grown on *Schleichera trijuga* (*kusum*), or when brood lac from this host is used to infect other hosts. When a host tree is inoculated in July the females are not ready to give a swarm till the following January-February. This crop is called *kusmi* or *aghani.*

Jewthi.—The larvæ from the *kusmi* crop settle down in January-February and the females do not mature till June-July. This is called the *jewthi* crop, and the larvæ infected on *kusum* or other hosts will give rise to the *kusmi* crop once again.

It will thus be seen that there are four distinct crops of lac during a year, and it should be noted that any lac, except that grown on *kusum*, will always retain the *katki* and *baisaki* seasons for its life cycle. In the same way lac grown on *kusum*, or grown on *kusum* and transferred to other hosts, will always retain the *kusmi* and *jewthi* seasons.

Host trees

A great deal of information has been collected regarding the best host trees for the cultivation of lac. The lac insect appears to be able to sustain life for a time on almost any tree or shrub, but it is only on a few species that it will thrive and reproduce itself, and it is on a still smaller number that the lac produced is of real commercial importance.

It is only possible in this Manual to deal very briefly with the various host plants used, and it must be understood that the following remarks are very general.

The lac grown on **Schleichera trijuga** (kusum) is of superior quality and the encrustation is thick. This lac often fetches as much as Rs5 per maund more than lac grown on other hosts. The **kusum** tree is not however gregarious, but is generally found thinly scattered over the forests, and lac cultivation on it is therefore rendered difficult.

Butea frondosa (*palas*) is very widely used for the growth of lac, as it is a common tree and is frequently gregarious and is often preferred for this reason.

Zizyphus jujuba (*ber*) is a hardy tree which is popular as a host plant. The lac produced is of good colour and quality.

Zizyphus xylopyrus (*ghont*) is also suited to the cultivation of lac.

Acacia arabica (babul) is the most important lac tree in Sind, but has not done well elsewhere.

Cajanus indicus (*arhar*) is an important host in Assam, but is not extensively used elsewhere.

Ficus spp.—A number of *Ficus* species can be used as lac hosts, but many are still in the experimental stages. Satisfactory results have been obtained with *Ficus religiosa* and *F. cunia.*

Pruning

The young larvæ prefer young succulent shoots, the bark of which is not too thick, on which to settle and feed. In order that there may be an abundance

of young shoots in suitable condition to receive the larvæ when the tree is inoculated, the trees must be pruned in the correct way and at the right time.

The correct time at which pruning should be carried out must necessarily vary with the species of tree dealt with and the locality in which the trees are situated.

The objects to be attained and the general method of pruning to be adopted will however remain the same in most cases.

In the case of trees already carrying a crop of lac, the cutting of the lac on the trees may be made to serve as a pruning, and if properly carried out a subsequent operation may not be necessary. When cutting lac, however, the main object is the collection of lac, and often very little thought is given to the effect that the cutting may have on subsequent shoot production. *Palas* and *ber* will stand fairly drastic treatment, but other hosts may be ruined by careless cutting during the collection of the crop.

Whenever a tree is pruned, either during the course of crop cutting, or crop cutting combined with pruning, or pruning alone, the following points should be borne in mind:—

(1) The general health and strength of the tree must be maintained.
(2) Branches over 1½" in diameter should not be cut as this weakens the tree, except in the case of old trees which have lost their vitality, when pruning is carried out to produce new wood at the expense of the old.
(3) Pruning should be carried out so as to keep the shape of the tree good and allow plenty of room for new shoots.
(4) The production of the largest number possible of long healthy shoots.
(5) All dead and diseased branches should be removed.
(6) The thinner the branch the nearer the main stem it should be cut.

Systematic cultivation of lac

Before any scheme can be drawn up for any area in which it is proposed to cultivate lac, it is necessary to ascertain the various host plants available and their number. The first step, therefore, is to count and mark the hosts available. In cases where the hosts are all of one species it will be necessary to divide the area up into blocks or coupes which can be used alternately. If an area is composed of say *ber* trees alone, it would be fatal to inoculate all the trees in July, as, when the crop is cut in October-November, there would then be no trees to inoculate. Further, coupes are necessary to give the host plants a rest period at intervals, as continuous use as a lac host makes a heavy drain on the vitality of a tree. It is impossible to lay down any hard and fast rules as to when or

for how long a tree must be rested, as conditions must necessarily vary according to species and locality.

A word must here be said about alternation, which consists in growing lac alternately on two different kinds of hosts. This is a method that is becoming increasingly popular and important.

Alternative cultivation is simple and may be explained as follows:—

If there are in an area two kinds of hosts A and B, A should be got ready and pruned and inoculated say in July. In the meantime B would be pruned and got ready for inoculation. In October-November part of the lac cut from A would be used to inoculate B. A is now rested, and in July part of the lac collected from B would be used to inoculate A and so on. In each case the surplus lac would be sold. Certain types of lac hosts lend themselves particularly well to this type of cultivation.

Distribution of lac

Of the lac produced in India, 90 per cent comes from the area comprising Chota Nagpur, the Feudatory States of Orissa, and the Central Provinces. Bihar and Orissa are responsible for more than half of the annual output of lac from India. Other lac-producing areas are Assam, Burma, Sind, the United Provinces, certain areas in Bombay and Madras Presidencies, Bengal, and to a small extent Rajputana, the Punjab, and Hyderabad.

Collection and storage

Lac can be collected in two forms, *ari* or *phunki*. The former term is applied to lac which is cut before the emergence of the larvæ, while *phunki* is applied to lac collected after emergence has taken place.

During collection, branches bearing lac, either *ari* or *phunki*, are cut or broken off from the tree and are carried in baskets to a depot. The lac can be sold in this form while still on the branches, but it is more usual to remove the lac by scraping, by soaking in water, by splitting the twigs (in the case of *ber* only), or in the case of *phunki* by pounding. In the above forms it is known commercially as stick lac.

It is then dried in the sun in layers not more than 4 to 5 inches thick and repeatedly turned over till dry. *Ari* lac, which is collected before the insects have swarmed, is full of moisture and requires careful treatment. If not carefully dried it tends to go 'blocky' and consolidates into a dense block consisting of a mass of lac, pieces of wood, and foetid animal remains. In this state it is difficult to wash out the dye and it is also difficult to melt without the addition of rosin to lower the melting point. Better class manufacturers will not as a rule touch lac of this kind.

After the lac has been dried it is carefully winnowed to remove sticks, bits of wood, sand, etc., and is then known as clean stick lac, in which condition it is usually sold.

The lac obtained from different species of hosts is usually kept separate as some kinds are more valuable than others, and shellac manufacturers like to buy the different kinds separately.

Shellac

Manufacture

The object of manufacture is to refine the crude lac and to remove the dye, animal remains, and other impurities, but care must be taken not to affect the essential qualities of the lac prejudicially during the course of manufacture.

The first step is cleaning and grading. The lac is handpicked, and broken pieces are separated from those still adhering to the parent twigs. The former is a pure product and is used for the manufacture of first quality shellacs. The pieces adhering to twigs are sifted through a No. 6 sieve, and that which passes through constitutes the lowest quality of unwashed grain lac. What remains in the sieve is passed through a stone mill, which breaks the lac from the stick, and is then winnowed by women who are adepts at getting rid of dirt, etc., while retaining the maximum quantity of lac.

The lac, now known as unwashed grain lac, is taken to the washing department, which consists of a cement floor on which stand rows of stone pots about 2′ 6″ high and 2′ 6″ in diameter. The inner surface of the pots is rounded and serrated. The grain lac is placed in the pots, covered with water and allowed to stand overnight. A man then stands in the pot and works the lac with his feet against the serrated edges and this crushes the cell and washes out the dye. Three such washings are usually given.

The clean grain lac is then dried, winnowed, and separated into three classes: large grains, medium grains, and small grains.

In the blending room, different kinds of lac are mixed in the proper proportions to give the correct quality of shellac to be manufactured, and great care is necessary to keep the quality constant. Canadian rosin is added to old or inferior stick lac, in the proportion of about 12 per cent, in order to lower its melting point, but this lac can only be used for low grade shellacs.

The blended lac is then taken to the firing room where it is poured into pipe-like bags about 30 ft. long and 2 inches in diameter. These bags are made of cotton and are of very close wove when high grade shellac is being made.

The chief operator in the firing room is the roaster, a very highly skilled workman, and he is assisted by the stretcher, also skilled, and by the bag twister, who is unskilled.

The fireplace is a dutch oven, in front of which is placed a smooth stone and at one end of which is a depression containing water.

The bag is stretched in front of the fireplace and the roaster sits at one end of the oven just out of the direct heat. The bag is rotated in front of the fire by the twister so that it is thoroughly and evenly heated throughout on all sides. The roaster then seizes the end of the bag in his hand; this results in the bag being twisted, and the melted lac is expressed through the cloth. As it exudes, it is scraped off and is thrown on to the flat stone, which is kept damp with water from the sunken depression. It is then repeatedly basted on the bag till it is thoroughly mixed and attains the right consistency by the evaporation of the water. If sheet shellac is to be made, the glutinous mass is then spread over an inclined porcelain cylinder 10″ in diameter and 2′ 6″ long, which is kept full of warm water.

It is spread over the cylinder with a palm frond by the stretcher, and is then polished with a cloth and carefully removed. The sheet is then seized by the stretcher with his feet, hands, and mouth and is stretched from its original size of about 2′ 6″ × 1′ 6″ to about 4′ or 5′ × 3′ to 4′, being warmed periodically in front of the fire to soften and anneal it. The process of manufacture is now finished, the sheets are allowed to dry and harden, and are then broken up into pieces. Irregular pieces, e.g. where the sheet has been held, are picked out for remelting.

When a bag has been worked out and contains a large amount of refuse, the roaster stabs the bag with a gouge and squeezes out the refuse, known as *kiri*, which is then pressed into cakes and sold for the manufacture of bangles.

The process of manufacturing garnet and button shellac is similar, but in the case of garnet shellac, the process is finished when the shellac is removed from the cylinder. It is not stretched but is allowed to set hard. In the manufacture of button shellac the shellac is scooped up from the bag in a U-shaped spatula and is poured on to a metal plate where it spreads into a flat button. Before these buttons set they are stamped with the firm's trade mark. The general principles of manufacture are usually as described above, though there may be slight variations in different localities. Mechanical methods have also come into use. In such cases solvents are usually used in preference to melting by heat, but the processes are manufacturing secrets.

Recent experiments carried out in the Experimental Factory at the Indian Lac Research Institute, Ranchi, have shown that with suitable supervision as regards cleanliness, at least 70 per cent of the shellac manufactured in India could be classified as fines and superfines, provided that the stick lac was not more than a year old when it reached the factory. Unfortunately, however, the price of shellac fluctuates considerably, and it is customary, in order to

obtain high prices, to store the stick lac, which rapidly becomes polymerized and deteriorates when stored in a hot climate, and after three to four years of storage is almost ruined for industrial uses. Shellac deteriorates relatively slowly in cool climates and, if the noted fluidity of the lac is to be retained in the shellac, the time that the material is kept in India, either as stick lac or shellac, should be reduced to a minimum. This property of high fluidity is of the utmost importance to the moulding and gramophone industries, which take over 50 per cent of the exported shellac.

Shellac is usually packed by shippers in two-maund wooden cases lined with cloth, though it is sometimes packed in double gunny bags. The grade of the shellac is usually marked on the case. It is not usually shipped during the hot weather and rains as there is then a danger of its arriving in a blocky condition.

The bulk of shellac which is manufactured is of a grade known as T.N., which is the standard of the trade. T.N. is pure shellac with a limit of 3 per cent insoluble impurities, and is the standard on which the price for all grades of shellac is based. Manufacturers of any importance have their own proprietary marks for the various grades that they manufacture.

Properties

The properties which make shellac the valuable article that it is are its insolubility in water and ready solubility in other cheap solvents; its comparative hardness amongst gums; its elasticity and power of adhesion to smooth wood and metal surfaces, on which it can be spread in very thin layers; its flux or power to assume with great exactness the shape of a mould to which it is applied; and its power of electrical resistance.

Uses

More than 50 per cent of the shellac exported from India is used by the moulding and gramophone industries, but it is also used for many other purposes, amongst which may be mentioned fine varnishes, polishes, sealing-wax, hats, emery wheels, munitions (cartridges and shells), electrical instruments of all kinds, and insulation.

Mention has already been made that shellac has to meet increasing competition from synthetic products and from the more extended use of plastics and cellulose finishes, and, if shellac is to hold its own, steps will have to be taken to improve the cultivation of lac and its manufacture. Research on these lines is being conducted at the Lac Research Institute, Ranchi, and there are also special officers on lac investigation in England, whose duty it is to keep in close touch with the requirements of the trade in Europe, to act as liaison officers between India and the consumers, and to try and find new uses for

shellac and improved methods of manufacturing shellac for different uses. It is only by this means that lac, which is India's most valuable forest product, will be able to hold its own in a world which is always searching for something new and something better.

XX

RESIN-TAPPING OF PINE TREES AND THE MANUFACTURE OF TURPENTINE AND COLOPHONY

Setting up the crop—freshening and collection of the resin—methods of tapping—the manufacture of turpentine and colophony—uses of rosin—uses of turpentine.

The tapping of *Pinus longifolia* (chir) for the production of resin is now an important forest industry in the United Provinces and the Punjab, where this species is common, and the Forest Department derives a very large revenue from the sale of resin to the two turpentine and rosin factories situated respectively at Bareilly and Jallo. These factories are under partial Government control and further revenue is derived from the shares which Government holds.

The resin of conifers occurs mainly in resin ducts, which run in a vertical and horizontal direction through the wood. The resin in the sapwood flows more copiously than that in the heartwood, where the resin ducts are often blocked up. If a pine tree is blazed, therefore, or in other words if a thin slice is taken off the outside of the sapwood, a number of resin ducts will be severed and the liquid resin contained in them will drip out.

This is the theory of practical resin-tapping, which is made use of throughout the world. The actual details may vary in different countries and in different localities but the theory remains the same.

The method of tapping employed in the chir forests of the United Provinces is representative of most of the resin tapping done in India under the control of the Forest Department. A description of this method of tapping is therefore given below.

The Turpentine and Rosin Factory at Bareilly intimates to the Forest Department, prior to 1 June each year, the amount of resin they are prepared to purchase during the next working season, and the Divisional Forest Officers are then told how much they have to produce from their respective Divisions. On receipt of this information the areas are selected in which tapping is to take place and, in the case of new areas, the trees to be tapped are marked and the number of channels estimated.

Arrangements are then made for all the tools, pots, etc., required during the coming season.

Setting up the crop

A great deal of preliminary work has to be done in order to have the trees ready for tapping at the commencement of the season, and this is known as 'setting up the crop'.

A tree to be tapped for the first time is marked with a figure to indicate the number of channels or blazes to be made on it and, in some cases, the exact position of the channel may be marked with a scribe. In the case of trees which have never been tapped, the first channel is always made on the south side and, if the tree is to carry two channels, they are made side by side $4\frac{1}{2}$ inches apart on the south side of the tree. If the tree already has one or more old channels on it, the new channels are made adjoining the old ones but leaving a space of $4\frac{1}{2}$ inches between the old and the new channels.

All the outer bark is then removed where the new channel is to be applied and a cut is made with a mallet and a curved chisel, about 8 inches broad, at a height of about 6 inches from the ground. Into this cut, a rectangular piece of galvanized iron, $6'' \times 2''$, is hammered, to form the lip, which conducts the resin flowing from the channel into the pot, or cup, below. The cut for the lip is made at a slight slant, so that the lip is slightly sloped to render the flow of resin easier.

The commencement of the channel is now made with a special adze perpendicularly above the lip, leaving about $1\frac{1}{2}$ inches between the chisel-cut for the lip and the bottom of the channel. The channel is about $6''$ long, $3\frac{3}{4}''$ broad and $\frac{3}{4}''$ deep.

In the case of trees which have been tapped during the previous year the old lips are removed, burnt to clean them of old resin, and hammered into shape; broken lips are rejected and new ones substituted. The chisel-cut is then made in the same manner as described above, but at a point 4 inches below the top of the previous year's channel.

All loose bark, which is likely in the course of the season to flake off and fall into the pot, is rubbed off above and alongside the channel. Deep cutting into the bark during this operation must not be done, except over a length of 6 inches above the top of the channel and a width of 5 inches where the channel is to proceed during the year. The excess thickness of bark in this case may be removed with the adze to leave only a thickness of $\frac{1}{4}$ inch of bark, care being taken that the grooves between the bark plates are so trimmed that dirty water will not run down them into the channel during the rains.

If considered necessary, shallow marks are cut in the bark upwards on the stem to show the direction in which the channels should proceed. They should proceed upwards parallel to the axis of the tree or to existing channels, but if this is impossible owing to a wound or knot or the tree being crooked, the channel is discontinued.

A nail is driven in about 1 inch below the lip, on which to hang the pot in which the resin is to be collected. These pots, made of unglazed clay and resembling a small flower pot, are 6″ high and 4″ broad at the top. They are covered with a lid, except the part immediately under the lip, to prevent pieces of bark and dirt from falling in and to stop evaporation of the turpentine contained in the resin.

The nail must be so driven that the pot is hung in such a way that all the resin will flow into it and must not be so placed that the resin can fall on it and run out of the pot through the nail-hole.

In the first year's coupes the pots may be hung at the same time that the channels are made, or they may be hung when the first freshening is made. The decision depends upon the amount of resin which will be lost by not hanging the pots immediately. Channels which are made early in the cold weather and in cold localities will probably give very little resin before the first freshening, others made later in warmer weather, or in warmer localities, may give appreciable quantities.

The final operation in the setting up of the crop is the removal from the base of the tree, for a distance of 4 feet, on all sides, of all resin, needles, chips of wood, etc. This is done to lessen the chance of the channel burning in the event of a forest fire. The needles, chips, of wood, etc., so removed should not be made into a heap below the tree, but should be well scattered.

It is essential that the crop should be set up in good time before the actual tapping is started and the latest date for starting the work is 15 January, while the work has to be completed by 28 February at the latest.

Freshening and collection of the resin

The tapping season proper lasts from March till November, as the resin only exudes in appreciable quantities while the weather is warm.

For freshening and collecting the resin not less than 1 cooly per 1,000 channels is necessary, and for this work he is supplied with the following tools:—

1 adze
1 lip-scraper and channel measurer
1 *balti* and strainer
1 ladder in the case of 5th year coupes

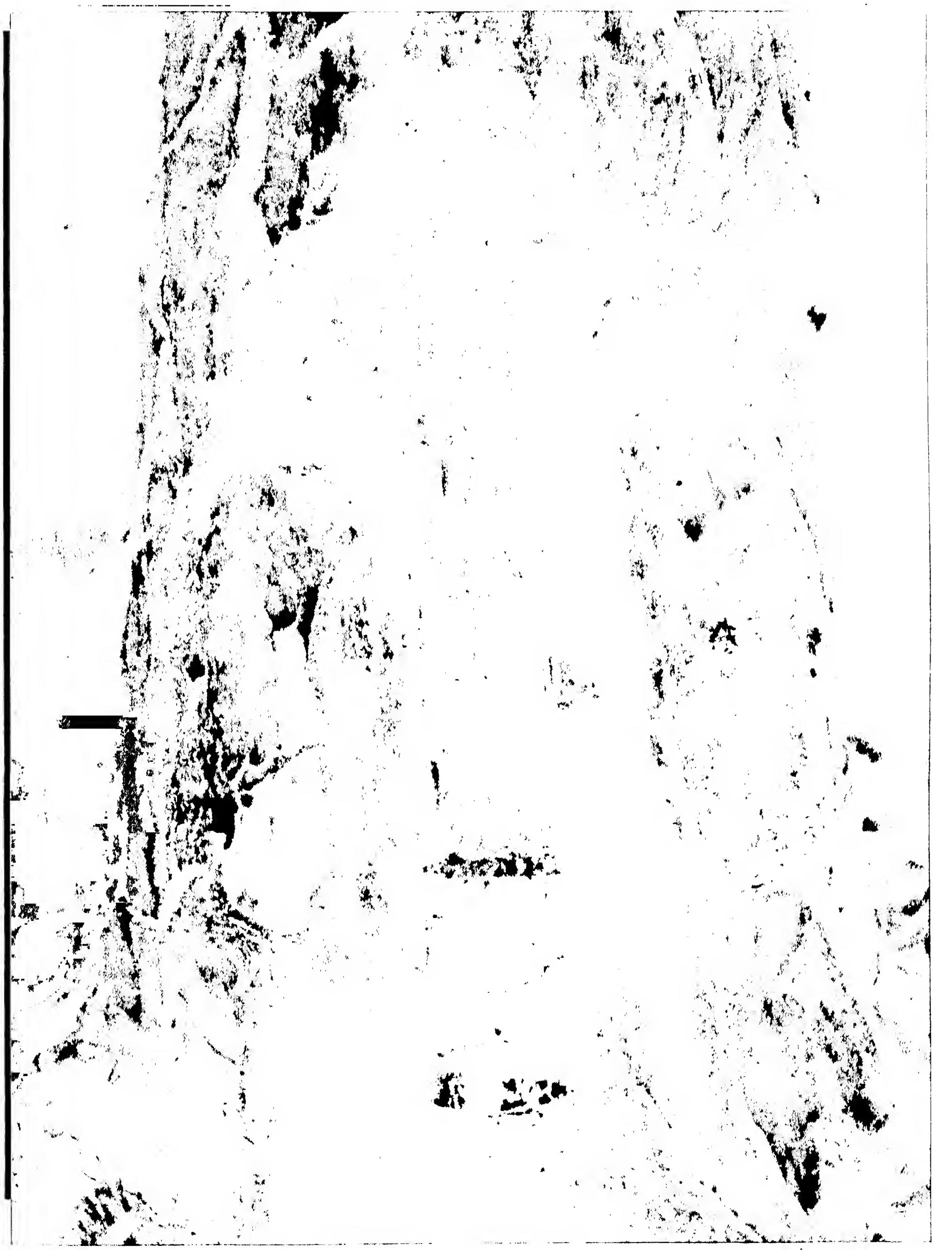


PLATE XVI. Resin-tapping, showing the flow of resin from the blaze

Facing p. 326.

PLATE XVII. Resin-tapping, showing collection of resin (*Pinus longifolia*)

Facing p. 327.

'Freshening' consists in removing with an adze from the channel a thin shaving of wood, so as to open up the clogged resin ducts. In this work the blaze must not be lengthened by more than ½ inch at each freshening, i.e. the strip of bark and wood that is removed from the top of the blaze must not be more than ½ inch in length. The shaving should rapidly taper off in thickness and should only be about 6 inches long. It must not be continued down to the lip, as this eventually makes the channel much too deep. The face of the channel must, however, always be kept clean and smooth to facilitate the flow of resin over the lip and into the pot. The depth of the channel, under existing orders, should never be more than 1 inch in the case of light tapping and 2 inches in the case of heavy tapping. These two different methods of tapping are referred to later. The adzes used for the work must be kept very sharp so that the cuts are clean, and the coolies usually carry a small stone with which to sharpen them.

Freshening commences not later than 1 March and is carried out at least every sixth day, i.e. a minimum of five freshenings are made in a month. In some places and at certain times of the year, it has been found that eight freshenings give a higher yield of resin. At the end of the year's work the channel should, therefore, be about 2 feet or more in length and should increase each year by about 18 inches. By the end of the 4th year the height of the channel will be such that in the 5th year the tapping cooly will require a light ladder to carry from tree to tree to enable him to reach high enough to carry out the freshening.

The resin is collected from the pot every time that a freshening is made and the procedure on arriving at a tree is as follows:—

(1) The lid is removed from the pot and is placed carefully aside so that it does not get broken. The pot is then gently removed from the nail and is placed upside down on the strainer in the *balti* to allow all the resin to drain out.

(2) The bark is chipped off so as to keep the surface bark ¼ inch thick for a distance of 6 inches above the top of the channel. All loose bark is rubbed off as was done in setting up the channel.

(3) The channel is freshened by removal of a thin shaving of wood as described above, and is tested with the channel measurer to ensure that it is kept the right size.

(4) All congealed resin is removed from the lip with the lip-scraper.

(5) All chips of wood, bark, resin, loose grass, needles, etc., are cleared away up to a radius of 4 feet on all sides.

(6) Any resin remaining in the pot is removed with a wooden spoon.

(7) The pot is replaced on its nail and the lid is again placed in position.

(8) If it is found that the resin is not flowing properly into the pot everything possible is done to rectify the matter, i.e. by adjusting the nail, bending the lip, or by fixing one or more chips of wood into cuts made in the bark at the side of the channel in order to guide the flow of resin.

The resin collected is taken promptly to the depot where it is poured into kerosene tins provided with a small hole. When filled, the kerosene tins are soldered up and are then dispatched to the Turpentine and Rosin Factory at Bareilly.

Methods of tapping

Two different methods of tapping are adopted; namely (1) light continuous tapping, and (2) heavy tapping.

Light continuous tapping.—At one time it was customary to tap the trees on any given area for 5 years and then to allow them 10 years' rest before being tapped again. This method has now been superseded by what is known as light continuous tapping. In an area taken up for working, all trees between 3′ 6″ and 7′ in girth are given one channel and those over 7′ two channels.

When a tree is first put under light continuous tapping the first channel (or two channels in the case of large trees) is cut on the southern face as this is the warmest and gives the best outturn of resin. This channel is kept in use for 5 years, being lengthened every year as described above. After 5 years' tapping a new channel is started 4½ inches to the left of the old channel and this is tapped for 5 years. At the end of the second 5 years another new channel is again made 4½ inches to the left, and so on, till tapping has proceeded right round the tree. As soon as the whole tree has been gone round in this manner, channels are started on the inter-channel spaces of 4½ inches which were left every time a new channel was opened. The same method is adopted when two channels are used, as on large trees, and the two channels are always placed 4½ inches apart.

Under this system a tree is always kept under tapping and is given no period of rest as was the case when the older method was employed. This light continuous tapping offers various advantages: it is simple, it gives a sustained yield from areas advantageously situated as regards labour, transport, etc., the labour in any area benefits as there is no hiatus in tapping, and finally, this method has been found to give better yields, while it has also been found that it does not impair the vitality of the tree.

Heavy tapping.—Heavy tapping or, as it is sometimes called, tapping to death, is adopted in areas where the trees are to be felled within 5 years.

In this case as many channels as possible are cut in the tree and it is tapped in this manner for the 5 years previous to being felled to obtain the greatest possible outturn of resin. Where areas are to be regenerated by natural means the seed-bearers are first marked, but under no circumstances are they tapped, as this weakens the seed production and the quality of the seed.

The timber of the lower part of trees which have been tapped throughout their life is naturally much spoilt by healed-over wounds, but the clear wood of a tapped tree is itself actually improved by tapping, being stronger, and according to American opinion, more easily seasoned. On the other hand, the timber of trees which have only been tapped immediately before they are felled does not show any appreciable difference either way.

The method of tapping described above holds good, with slight variations, for all the Indian pines, and is based on the French system of tapping which has been in practice for centuries.

The manufacture of turpentine and colophony

Crude pine resin consists of two principal constituents, a liquid known as oil of turpentine, and a solid (at ordinary temperatures) known as colophony or rosin.

These two substances can be separated by distillation, under the action of heat; the oil of turpentine passing over as a distillation product and colophony remaining behind as a residue.

The two large Rosin and Turpentine Factories in India are situated at Jallo in the Punjab and at Bareilly in the United Provinces.

The crude resin, on arriving at the distillery in containers, is in a very impure state, and though every care is taken in the forest to keep it clean, it contains water, chips of bark, pine needles, insects, and dirt. To empty the tins they are placed upside down on a grid in a large retainer, which is heated by steam so as to melt the resin sufficiently to allow it to run out. It is passed over a strainer which gets rid of all but the smaller impurities, and then equal parts of turpentine are added, that is, the quantity of turpentine added is equal to the amount which the crude resin already contains. This is done to further liquefy the resin so that the finer particles of dust can be got rid of. The whole mass is then mixed and allowed to settle in a vessel with a light lid and a pointed-shaped bottom along its length, and kept heated by a steam jacket. Due to the complete liquefication of the heated resin, the fine particles of dust which it contains settle into the V-shaped bottom of the tank, and the pure resin is run into a measuring tank, leaving the sludge in the settling tank. The necessity of a measuring tank is so that, by knowing the exact quantity of each charge, standardized methods of distillation can be adopted. The mass is then pumped

from the measuring tank into a steam-jacketed copper pressure still, fitted with a steam spray inside and a swan-neck connected to a condenser, between which it is advisable to insert a catch still, to catch any very heavy oils which it is desirable to eliminate at once from the distillate. Live steam is then let into the still through the rose spray pipe, and the mass is heated by aid of the steam jacket and distillation commences. The duration of the process depends on the size of the stills and charge inserted, and may last for two or more hours. The lighter oils come over first, followed by the heavier fractions. The still is then cut, that is, the better oils having been recovered, only a small percentage of heavy oils are left, together with a considerable quantity of condensed water and the rosin. The heat and pressure are then raised to get rid of the small fractions of heavy oils and the water, leaving the pure rosin in a molten state to be run off and packed into containers after careful straining through sieves packed with cotton wool.

The turpentine is then re-distilled in an ordinary non-pressure copper steam still, so as to fractionize it into first-, second-, and third-quality oils. The amount of turpentine and rosin obtained varies considerably, according to the period of the year at which the resin is collected. In the case of resin collected in May or June, the yield of turpentine may be 20 per cent, falling to 15 per cent on resin collected later in the year or on resin which has been allowed to stand over for a considerable time. The rosin obtained is about 67 per cent, while impurities and water amount to about 13 per cent.

Uses of rosin

Colophony or rosin is used in every country in the world for many purposes. The chief supplies come from Europe and America, but the Indian trade is increasing annually, and laboratory research work has of late years greatly improved the quality and outturn of this product, so that Indian rosin can now hold its own in the world's markets.

It is used extensively in soap-making and is also in great demand for sizing paper and cloth. It gives to certain kinds of paper a stiff coating or surface, making them adaptable for printing and writing purposes, without which it would be impossible for certain papers to take colours, inks, etc.

Rosin is also in great demand for a wide variety of manufacturing enterprises, particularly in the making of linoleum, sealing-wax, oilcloth, special flooring compounds and coverings, lubricating compounds, and various kinds of inks. It is extensively used for soldering, as a drier in the manufacture of paints and varnishes, and as a dressing for machine belts and the bows of violins and 'cellos.

Uses of turpentine

The oil of turpentine now produced in India is, owing to improved methods of distillation, of a very fine quality, and has been accepted as equal to foreign supplies by the chief Indian consumers.

By far the largest part of the turpentine made in India is consumed in India, where it is chiefly used in the preparation of paints and varnishes, and is also largely employed in certain medicines and for dissolving fats, resins, and caoutchouc.

A certain amount is, however, available for export, and it would appear that there should be a favourable market in Australia and Java, which are now supplied by America. This is due to there being regular steamship services between America and Java, with the result that the freight is very much lower than from India, in spite of the fact that India is actually closer. Indian turpentine cannot, therefore, compete with American turpentine in the Java market at present, and it is found more advantageous to send surplus supplies to England in spite of the heavy freight.

The whole of the Indian rosin and turpentine industry is under partial Government control, and as the sustained annual gross revenue of chir forests worked for resin-tapping alone is about three rupees per acre, this industry affords a striking example of the possibilities of a minor forest product.

XXI

CHARCOAL-BURNING

IN RETORTS. IN OPEN PITS. IN KILNS; **the paraboloidal overground kiln—oven kilns—pit kilns—prismatic kilns—hill kilns—portable metal kilns.** CHARCOAL.

The manufacture of charcoal, or charcoal-burning as it is more popularly called, is a form of destructive distillation of wood, and consists in burning wood out of contact with the air. If wood is burnt in the presence of air it is converted into various gases which go off in the form of smoke, and only a small quantity of ash is left behind as a residue. If air is largely excluded during the burning, combustion is much retarded and the wood is only partially burnt or carbonized, the solid residue left behind being known as charcoal.

There are three methods of making charcoal: (1) in retorts, (2) in open pits, and (3) in kilns.

IN RETORTS

An account of the destructive distillation plant at Bhadravati in Mysore, at which charcoal is manufactured in retorts, has already been given on page 263 and the future prospects of adopting this method of manufacture have also been discussed. It is, therefore, unnecessary to deal with this question again here, but it may be noted that portable or semi-portable apparatus for the manufacture of charcoal in retorts, with recovery of the by-products, has been designed and put into use in France. Such apparatus is not, however, likely to find a wide use in India. It may also be mentioned that charcoal produced in retorts is usually of better quality than charcoal produced in kilns.

IN OPEN PITS

This is a very wasteful method of making charcoal and is never employed on a large scale. It has the advantage, however, of producing charcoal in a very short time, and very little skill is required to carry it out. A hole about 5 feet across, with sloping sides, is dug in the ground to a depth of about 4 or 5 feet. This is filled with dry twigs and sticks which are then lit and allowed to burn, until all smoke has ceased. More sticks are then thrown in and the operation is repeated, until the pit is full of glowing charcoal, when it is covered over with turf or mud so that all air is excluded. It is then left to cool down,

and at the end of a day or so is opened up and the charcoal removed. The charcoal thus made is not of good quality, being burnt half the time with free access to the air, but this method has the advantage of turning out small charcoal quickly without any lengthy preparations, so that if charcoal is required at once for some special purpose, it is often adopted. It is often employed during road-making and similar works, when charcoal is required in a hurry for mending tools.

In Kilns

This is an important industry and provides a livelihood to forest dwellers in many parts of India. The work is generally in the hands of a contractor, but the right to burn charcoal is often sold annually to responsible forest villagers. It is purely a local industry, and the methods employed vary in different districts. The principle is, however, the same in all cases, and before describing briefly the different types of kilns used in India, the following general rule must be understood.

In the first place, all the wood used should be carbonized as far as possible simultaneously, otherwise the first pieces alight would be completely burnt up before the last pieces alight are half carbonized. To ensure even carbonization, the pieces of wood used should be as uniform in size as possible, and no unsound wood should be included. The ideal method is to use billets of one species only, or different species of approximately the same density. In order to allow as little air as possible in the kiln, the billets of wood should be dressed straight and stacked as close together as possible. The method of stacking may vary with different types of kilns, the shape of the kiln having an important bearing on this point.

The different types of kilns used in India are as follows:—

(1) The paraboloidal overground kiln.
(2) The oven kiln.
(3) The pit kiln.
(4) The prismatic kiln.
(5) The hill kiln.
(6) The portable metal kiln.

The paraboloidal overground kiln

Of these six types, the paraboloidal kiln is the best known and most commonly used in India. It is built in the shape of a paraboloid, the volume of which is roughly $\pi r^2 \times \frac{h}{2}$, or in terms of the circumference (C) the volume is $\frac{C^2h}{8\pi}$. In size these kilns vary considerably; depending on the amount of

charcoal required. A convenient size of kiln is one with a radius of 8 to 10 feet and about 8 feet high. This gives a capacity of roughly 800 to 1,200 stacked cubic feet.

Site.—The site for a paraboloidal kiln must be level and even, and should be in a sheltered place near to water. The soil should not be too stiff nor too porous, a sandy loam being about right. If too porous it allows air to penetrate, and if too stiff it does not absorb the liquid products of carbonization. All vegetation should be removed by the roots, and the ground should be uniform with the centre of the site raised about 8 inches and sloping evenly to the circumference, so that any liquid products not absorbed by the soil can run out to the edge. If the site is at all damp, dry leaves or brushwood should be burnt on it, in fact the best site of all is an old site which has been previously used for charcoal-burning. Better results are likely to be obtained if a new site is allowed to settle for 2 or 3 months before being used, but this is rarely done in practice.

When taking an old site into use, the small pieces of charcoal found lying on the surface should be broken up and well mixed with the soil before it is prepared for use as described above.

Building the kiln.—This type of kiln is usually built up with two tiers of vertical billets and a top layer of horizontal billets. If the vertical billets are cut 3 feet long and the horizontal billets are stacked 2 feet deep, the kiln will then be 8 feet high which, as stated above, is a convenient height. Before stacking is begun, it is necessary to construct a flue or chimney up the centre. This is done by driving three stakes into the ground in the centre of the site, the stakes being a foot apart and forming an equilateral triangle. These stakes, which should be at least as high as the top of the kiln, are then bound round with twisted grass so as to form a hollow chimney. This chimney is then filled up with dry grass, straw, twigs and other easily-burnt material.

This type of kiln may be fired from above or from below. If firing from below is intended, a narrow passage must be left from the centre chimney to the outside of the kiln. This is usually done by laying a straight pole along the ground, and stacking billets in the form of an X above it, the pole being withdrawn when the stacking is completed thereby leaving a horizontal flue below the billets. To ensure a correct shape for the kiln, the circumference is marked out on the ground with pegs in the form of a circle.

Stacking then commences from the centre, with a few thin billets placed round the centre chimney to ensure easy firing. The other billets, all cut to length and trimmed, are then stacked as closely as possible round the centre. The thick end of the billets should always be on the ground, so that the thin ends are sloping slightly inwards giving the paraboloidal shape to the kiln. The thickest billets should be stacked about half way out from the centre, this

being the place where the heat is greatest, and all interspaces should be filled up with small chips and pieces of wood.

The second tier is stacked in exactly the same way as the first, always bearing in mind the correct slope and shape of the finished pile.

The third tier is stacked with the billets lying horizontally on the second tier, various lengths being used to give a rounded top to the stack.

Covering the kiln.—The best covering for a kiln of this type consists of two separate layers. The inner layer is usually made of turf, green grass, leaves, ferns, or moss, and must be sufficiently thick and well-packed to hold up the outer layer which is made of wet earth, or preferably of fine earth and charcoal dust mixed. This outer covering is plastered all over the kiln so as to exclude all air. This type of covering has been found quite satisfactory as it is fairly substantial and air-tight, and at the same time it is pliant enough to give slightly as the interior stack subsides during the burning.

The outer covering is sometimes kept in position by horizontal poles supported by upright forked sticks, two or three tiers sometimes being employed.

Firing the kiln.—Firing is usually done from the bottom of the kiln, as the fire then spreads quickly outwards and upwards throughout the kiln, whereas firing from above often results in the fire failing to reach the lowest parts, resulting in incomplete carbonization of the charge. Firing from below is done by pushing a pole, with a bundle of burning straw tied to the end of it, along the passage left for the purpose under the X-stacked billets of the bottom tier. The material in the chimney is thus set alight, and the surrounding billets begin to burn. To ensure the kiln being well alight, more dried shavings, straw and chips of wood are pushed into the chimney from the top, and when these have burnt up the chimney is filled up with short billets, to prevent the stacked material from falling in. The lighting passage is then also filled up with billets, and if the kiln is well alight the entrance to the firing passage, as well as the top of the chimney, are covered over with grass and mud.

The burning of the kiln.—When the kiln is well alight, the fire spreads outwards from the centre in the form of an inverted cone with the base gradually widening outwards. Theoretically, burning should proceed evenly all round the kiln but in practice this seldom happens. The first sign that burning is in progress is a bluish-grey vapour issuing from the surface of the kiln, and if all is well this is shortly followed by a thick pungent yellowish-brown smoke which continues till carbonization is complete, when a clear blue flame appears all over the kiln.

The time taken to complete carbonization naturally varies with the size of the kiln, the size of the billets, and other factors, but the usual period is from about 7 to 10 days for a normal kiln. During the whole of this time the progress

of the burning has to be carefully watched and controlled, and the quality of the charcoal made depends almost entirely on the skill and care of the charcoal-burners during this time. If burning proceeds too quickly the outer covering of the kiln has to be thickened. If burning is too slow small holes are made with a stick, just in front of the line of burning, to allow some air to enter and accelerate combustion. These holes are filled up as soon as a blue flame emerges. In order that the burning may proceed as evenly as possible the circle of smoke is watched and attempts are made to keep it at the same level by speeding up or retarding the burning as described above. All cracks and hollows formed by the subsidence of the outer covering, due to the loss of volume of the burning stack, must be filled up at once. All this means careful and continual watching, especially at night when cracks are clearly visible by the glow of the fire inside the kiln.

A screen of branches, leaves, etc., is sometimes erected on the windward side of the kiln to protect it. A strong wind makes control of the burning extremely difficult, and screens are frequently erected before the kiln is even lighted.

Opening the kiln.—When the clear blue flame has appeared right down at the base of the kiln, carbonization is complete, but the kiln is not opened at once as the charcoal would burst into flames. Very often a week or more is allowed to elapse before the kiln is opened, and even then, the opening is a time of great anxiety and has to be carried out with the utmost care. For this reason, the opening is often done at night, when smouldering pieces of charcoal can be seen at once. A small hole is usually made first in the side of the kiln, and some charcoal is raked out and the hole quickly covered up. If all is well this is repeated round the kiln, until all the charcoal has been extracted. If any of the extracted charcoal is glowing, it is at once covered with wet earth or sprinkled with a little water. Water should be used sparingly, however, as it spoils the quality of the charcoal. This precaution is often ignored and instances are not uncommon when copious supplies of water are used to quench the charcoal from kilns opened in the heat of the day. When the charcoal is cool enough to handle it is sorted and put away under cover and the operation is completed.

Oven kilns

The distinguishing feature of oven kilns, which are frequently seen in Oudh and at Changa Manga in the Punjab, is the thick covering of mud, which becomes baked into a hard crust at the first burning and which is afterwards kept as a permanent kiln. Oven kilns are usually similar in shape to paraboloidal kilns. In some localities they are built completely above ground, while in others they are built over a circular hole about 1½ feet deep. They are fired through holes

in the covering at ground level, and the hollows formed during the burning of the first charge are not filled in and the covering is allowed to bake hard into the form that it assumes. The charcoal is always extracted through the same opening in the side of the kiln and the rest of the wall is left intact as a permanent oven. The yield of charcoal from the first burning is always less than from subsequent burnings.

Pit kilns

A pit kiln is similar in shape to the paraboloidal kiln, but in this case the lower part of the kiln is within a pit dug in the ground. If the pit is deep, vent holes are dug obliquely through the ground to the bottom of the pit. At the bottom of the pit is spread a layer of dried leaves and twigs to ensure the spread of the fire and to absorb the liquid products. Stacking is usually horizontal, some billets being placed radially and some tangentially. A chimney is left up the centre of the kiln, which is fired from the top, and the sides are usually kept open at ground level until the fire has spread below the surface. The advantage of these kilns is that the area of kiln covering to be attended to during the burning is reduced, thereby helping to exclude the air.

Prismatic kilns

The name given to this form of kiln hardly describes its shape. It is really rectangular with rounded sides. The wood is stacked horizontally, and this kiln therefore has the advantage of accommodating long pieces of wood, thereby doing away with the necessity of cutting up billets to required lengths. Very large kilns of this type are frequently constructed in the Central Provinces, logs of very large sizes being built into the kiln. These kilns have no chimney, and a passage is left along the ground from end to end of the kiln and filled with combustible material. The kiln is fired either from the centre or from both ends. The kilns are very easy to construct but are difficult to cover, the covering being very liable to breakage by uneven settling. For this reason the outturn of charcoal obtained is frequently very low.

Hill kilns

Hill kilns are merely an adaptation of other types of kilns to suit hilly country where level sites are difficult to find. A cutting is made into the side of the hill so that the ground slopes outwards at an angle of about 60°. The site should be allowed to settle, as the outer portion is usually of made-up earth. A passage is left along the ground from the front to the back, and is used for firing the kiln, and connects with a vent hole at the back. The billets are usually stacked horizontally and, as carbonization is more rapid on the valley side

exposed to the wind, the kiln is usually made highest towards the outside, and in this portion the largest billets are stacked. The outer face is frequently supported by horizontal billets held in position by forked sticks. Even if precautions are taken in stacking, burning is apt to be uneven, as the front side of the kiln is exposed to mountain winds while the other side is up against the back of the cutting in the hillside.

Portable metal kilns

The manufacture of charcoal in the various types of kilns described above is limited in its application, calling as it does for skilled burners, suitable sites close to water, and favourable weather conditions.

In order to overcome these difficulties, increased use is being made of portable metal kilns in which metal plates replace the covering of leaves and earth used in other types of kilns. Portable metal kilns are composed of metal plates joined together to form the sides, the top being closed by a metal roof or cover. The plates or panels vary greatly in size and shape in the different types now on the market and are joined together by different devices, nearly all of which provide for the formation of a column of earth or sand to render the joints air-tight.

The roof is usually composed of sections, for ease of transport, and the joints between the various sections are made airtight by an earth joint, provision being made for the escape of the gases and smoke formed during carbonization.

The air necessary for carbonization is admitted through the base of the panels or through air inlets sunk in the ground below them. These air inlets are provided with means of regulating the amount of air admitted.

When dismantled, the kilns can easily be carried in country carts and, in some cases, where the component parts are small and light enough, they can be transported over long distances by coolies.

On arrival at the site where the kiln is to be erected, the ground is first levelled and the side panels of the kilns are then assembled. In some models a special doorway is provided for loading and unloading, while in others one of the panels is removed to form a doorway. The first two layers of billets are stacked vertically and the uppermost layers horizontally. When stacking has proceeded up to the doorway, the door is placed in position and the stacking is completed by loading the material from the top of the kiln.

As soon as the kiln is full, the roof sections are placed in position and all earth joints filled up. The kiln is then fired either from above or below, the former practice being the more common. In this case glowing charcoal or burning embers are thrown down a special funnel, which runs down the centre

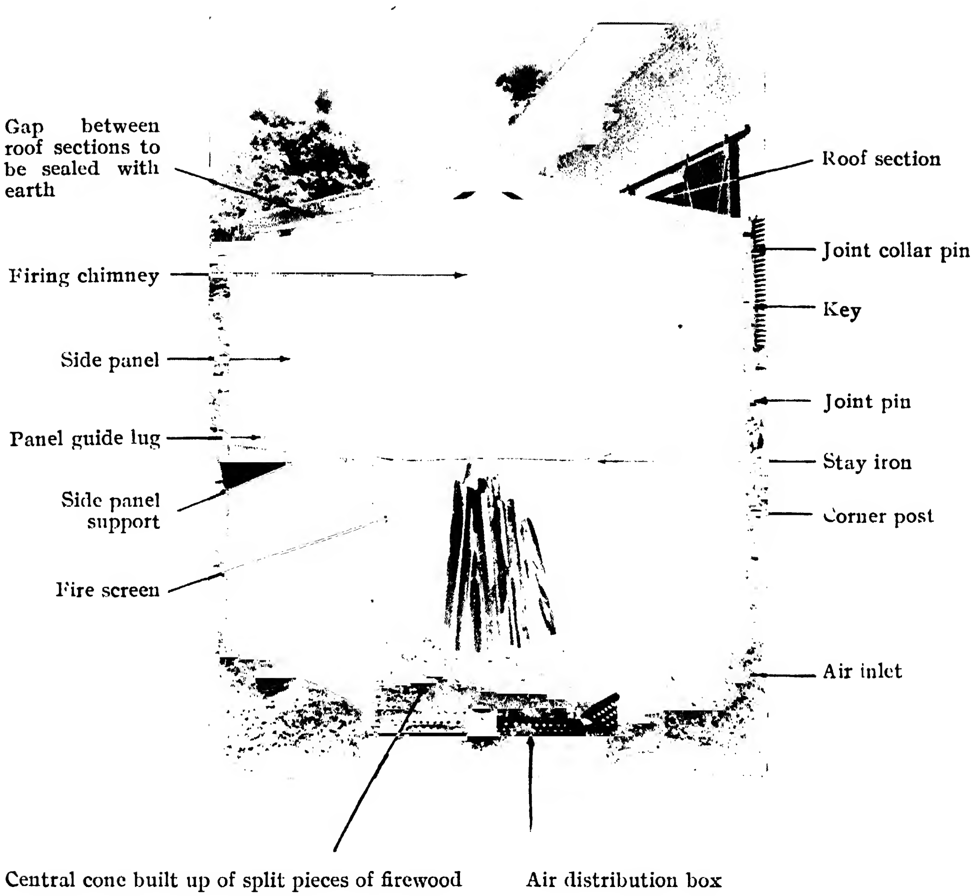


PLATE XVIII. Portable charcoal kiln

Facing p. 338.

of the kiln, this funnel being placed in position before stacking is started. The funnel having been removed, the glowing embers come in contact with the inflammable material placed at the base of the hole thus formed. The hole made by the withdrawal of the chimney is filled up with billets and is then closed with a cover, the smoke and gases passing out through the outlets provided. The air inlets are then opened and the amount of air admitted is so adjusted that the kiln gives off a dense white smoke.

Once such a kiln has been lighted it requires very little attention, and all that is necessary is the shutting down of the air supply on the windward side should a wind spring up. Some kilns are automatic or semi-automatic in action and do not even require this small attention. The kiln continues to burn until it is noticed that only a little blue smoke is issuing from the outlets, a sign that carbonization is complete. All the air inlets and the outlets for the smoke are then closed and covered with earth to make them airtight, and the kiln is left to cool down.

When cool, the kiln is opened and, provided that it has been made really airtight and has been given sufficient time in which to cool, no trace of fire will be found and the charcoal will be quite cool and easy to handle. The charcoal is then discharged and is allowed to stand in the open for 24 hours before being bagged. The kiln can be immediately recharged and lighted and a fresh charge burnt.

The advantages that these metal kilns offer over the ordinary 'country' methods of burning charcoal may be summarized as follows:—

(1) No water is required for their operation and they can be employed anywhere except on bare rock.

(2) They are not dependent on climatic conditions, as they can be operated in heavy rain or in a high wind.

(3) An ordinary cooly of average intelligence can be taught to operate them in a very short time, and there is no necessity for the services of professional charcoal-burners.

(4) They are automatic or semi-automatic in operation and do not require to be watched. The coolies are thus free to prepare material for further charges or can devote their time to the loading and unloading of other kilns. For this reason it is better to operate these kilns in batteries, as several such kilns can be attended to by two or three men.

(5) The outturn of charcoal is higher than that from ordinary 'country' kilns and the charcoal is also of better quality. Less charcoal is lost in the shape of breeze or dust, as the charcoal is cold and easy to handle when discharged.

(6) The kilns can be moved from locality to locality as required, thereby saving the expense of conveying the material to be carbonized to a site near water, as is necessary in the case of 'country' kilns.

(7) The danger from fire is greatly reduced if not completely eliminated, and these kilns can be used with absolute safety when the burning of 'country' kilns has had to cease on account of fire hazard.

There are, however, two disadvantages:—

(1) The high initial cost, and

(2) The limitation of the size of the billets that can be used in such kilns.

The main factor preventing a more extended use of these kilns in India has been their initial cost. No kilns of this type are as yet manufactured in India, and those used have had to be imported, chiefly from France, where great strides have been made of late years in the production of kilns of this type. To the initial cost therefore has to be added the cost of freight and import duty, so imported kilns are expensive by the time they eventually reach the purchaser.

A portable metal kiln suitable for Indian conditions has however now been designed, and an experimental model constructed, at the Forest Research Institute at Dehra Dun. This kiln has been constructed of materials easily available in the Indian markets, and prolonged trials have given very satisfactory results. It is hoped that it may be possible to produce these kilns in India comparatively cheaply and that they will then be used more extensively.[1]

Charcoal

As explained above, charcoal is carbonized wood. The actual yield of charcoal from a known amount of wood varies with the species of wood used and the method of carbonization employed. Dry wood produces more charcoal than wet wood of the same species, but a fair yield of charcoal from any wood may be put at between 20 to 30 per cent of the original weight.

The quality of charcoal naturally varies with different species. All woods produce charcoal of a kind, but the most important factor for a given species is the skill and care with which the burning is carried out. Good charcoal is a dry, black, porous, but fairly hard substance and should exhibit the following qualities:—

(1) A black and glistening appearance with a bluish tinge.

(2) It should give a clear metallic note when struck on a hard object.

(3) It should be free from taste and smell.

[1] Since this was written, several kilns have been manufactured in India, and are now in use.

(4) Small pieces should adhere to the tongue.

(5) It should be possible to rub the transverse face without soiling the fingers.

(6) It should be easy to light and should burn quietly without the production of smoke or flame.

Charcoal which has not been completely carbonized is reddish in colour and burns with much smoke. It is then known as foxy charcoal.

The superiority of charcoal over ordinary wood is due to the intense, steady and prolonged heat obtained from it, the ease with which it lights, and the absence of any smoke when it burns. For these reasons, it is extensively used for ore-smelting and for blacksmiths' and metal-workers' forges. Fine powdered charcoal is also used in the manufacture of black gunpowder. In India, it is employed in almost every house for cooking and heating purposes, and is perhaps the most extensively used of all minor forest products in this country.

XXII

PULP- AND PAPER-MAKING

RAW MATERIALS

Qualifications—Indian materials—*sabai* grass—other grasses. BAMBOO; periodic flowering—felling—extraction. CONVERSION INTO PULP.

PAPER-MAKING

Cleaning—digestion—bleaching—beating—felting—manufacturing site—classes of papers—costs of manufacture—prospects.

The art of paper-making was invented in China about 105 A.D. From China it was transmitted across India to Persia and Arabia, and thence to Spain and other parts of Europe. Until the close of the eighteenth century, paper was made entirely by hand, sheet by sheet. The device now known as a paper machine, and which is the basis of modern paper-making, was perfected in the beginning of the nineteenth century. The development of the paper machine and of the chemical and mechanical processes for the manufacture of pulp, stand out in the history of modern civilization as amongst the most remarkable inventions of the nineteenth century. These inventions placed at the disposal of humanity a cheap medium for the dissemination and preservation of knowledge and, by affording opportunities to each generation of starting its climb from the shoulders of the preceding generations, helped in the rapid growth of civilization. In fact, if every paper product and record were destroyed today, civilization would vanish like a puff of smoke. Paper is an essential commodity in the economy of modern life.

RAW MATERIALS

Qualifications

A sheet of paper consists mainly of minute vegetable fibres of different lengths and sizes, felted and intertwined with each other, and deposited in layers so as to form a sheet or web with a surface smooth enough to write or print upon. Theoretically, therefore, the sources of paper-making materials are almost unlimited, since almost every kind of forest or agricultural product can be utilized for the purpose. Practical commercial considerations, however,

limit the choice of materials considerably. The essential features for materials suitable for paper-making may be briefly summarized as follows:—

(1) Plentiful and sustained supplies of the material must be available so as to ensure adequate and uninterrupted supplies for mills dependent on it.

(2) The total cost of extraction and collection of the material and its transport to the mill site must be such as the industry can bear. Since only the cheapest materials can be used for paper-making, those which grow in inaccessible regions or which are widely and thinly scattered, or for which cheap means of transport are not available, or those which find better and more profitable uses in other trades and industries, are ruled out of consideration.

(3) (*a*) If the material is required for the production of 'cellulose' or chemical pulp, it should be sound in condition, i.e. free from knots, rot, and other defects. Further it should be relatively free from resins, gums, tannins and other substances, so that it is possible to isolate fibres or pulp from it with a minimum expenditure of steam and chemicals.

(*b*) If the material is required for the production of mechanical pulp it should be (i) white or light coloured, (ii) capable of being ground without splintering, (iii) low in resin content, (iv) reasonably free from knots, and (v) free from rot, pitch pockets and other defects.

(4) The ultimate fibres obtained from the material must be long and strong, and yet soft and tender enough to possess good felting properties. The average length of fibres should not as a rule be less than 1 millimeter.

(5) The material should contain as large quantities of 'cellulose' as possible, so that it is possible to manufacture pulp from it at an economic cost.

Indian materials

A very large number of agricultural products available in this country are at once eliminated for the paper industry if judged according to the above considerations. They are either not available at an economic cost or are refractory to chemical treatment, or the yield of pulp from them is low and of poor quality. The use of waste cotton, flax, jute or hemp, all of which have been employed by the industry as subsidiary materials in limited quantities and for special purposes, will of course continue as in the past, for so long as better and cheaper substitutes are not found for them.

Of the forest products available in this country, only those belonging to the Natural Order of *Gramineae* fulfil all the above conditions. Woods, both coniferous and deciduous, are not a practical proposition *at present.* Owing to lack of transport facilities, conifers, though excellent materials for paper-making and existing in enormous quantities in the Himalayas, are not readily available at an economic cost. In the same way, available supplies of single species of deciduous trees are not adequate to warrant their commercial exploitation for pulp or paper manufacture.

Sabai grass

Among the *Gramineae, sabai* grass (*Ischoemum angustifolium*) has been the staple Indian raw material for paper-making since the inception of the machine-made paper industry in this country as far back as 1870. *Sabai* is a perennial grass which grows plentifully on the bare slopes of the foothills of the Himalayas, as well as in parts of Bihar, Orissa, Bengal and the Central Provinces. The principal areas from which this grass is exploited for the paper industry are: (1) the Siwaliks (Eastern and Western Forest Circles, United Provinces), (2) Nepal, (3) Sahebgunj, and (4) Chota Nagpur and neighbouring States. The supplies of economically available *sabai* grass are, however, not sufficient to meet the future needs of the paper industry in this country.

Other grasses

A number of other grasses which are widely distributed and gregarious are, however, available in the country, e.g. *Saccharum spontaneum, S. arundinaceum, S. munja, S. narenga, S. fuscum, Anthisteria gigantea, Phragmites karka, Arundo donax, Desmostachya cynosuroides,* etc. Some of these have been investigated for paper-making in the past, but they have not always been found suitable for the production of bleached papers. It is, however, probable that in the light of recent technical developments, profitable uses may be found for these grasses, if not for bleached papers then for cheaper grades of papers, wrappings, boards and other cellulose products. Recent experiments on *Anthisteria gigantea* (ulla grass) show that this grass is suitable for the production of bleached writing and printing papers. It does not seem likely, however, that any of these grasses will replace *sabai* as the staple grass for the industry.

BAMBOO

The future development of the industry, based on supplies of indigenous raw materials, would have been faced with a grave crisis had it not been for the investigations on bamboo (also belonging to the *Gramineae* Order) carried out at the Forest Research Institute at Dehra Dun during the last 25 years. These

investigations have definitely and conclusively established the possibility of utilizing bamboo for the manufacture of a large variety of papers. Abundant supplies of the material, associated with excellent facilities for exploitation and transport, are available in different parts of the country such as in Burma, Assam, Bengal, Bihar, Orissa, Madras, Bombay, and Travancore. Some of the most promising forest areas in these provinces have already been surveyed, and it is estimated that a sustained supply of at least two million tons of bamboos are available in India for paper-making. So far, detailed investigations have been carried out on *Dendrocalamus strictus*, *Melocanna bambusoides*, and *Ochlandra brandisii* bamboos. In addition *Bambusa arundinacea*, *Bambusa polymorpha*, *Cephalostachyum pergracile*, *Dendrocalamus hamiltonii*, *Dendrocalamus longispathus*, *Bambusa tulda*, *Teinostachyum dullooa*, and *Oxytenanthera auriculata* have also been tested and found suitable for paper manufacture. Several of the paper mills in the country are already using bamboo for the manufacture of paper, and it is already a staple raw material for the industry.

The following factors are of importance in connexion with the exploitation of bamboo for the paper industry.

Periodic flowering

It is well known that when a bamboo flowers and produces seed, it dies. Some species of bamboos flower sporadically in patches every year. There is obviously no serious danger of an interruption of supply with these species. Other species flower gregariously, the seeding cycle of the leading species varying from 34 to 65 years. In the case of such species also, there is little risk of stoppage of supply for the following reasons:—

(1) The flowering of a species is spread over a period of 5 to 12 years. The period required for the establishment of the new crop from the seedling stage almost coincides with this period. Therefore, by the time the last patches in a given area flower, the new crop from those which flowered first is already established. A continuous supply of raw material is thus assured.

(2) In most areas, two or more species usually occur together, and their seeding cycles do not as a rule coincide. Thus when one species flowers, others are available to fill the gap temporarily created.

(3) Any deficiency in supply that still remains can be filled by the bamboos that have flowered. Such bamboos, unless badly attacked by fungus or borers, are quite suitable for pulping purposes.

The flowering of bamboos is, therefore, not a serious factor as far as continued supply of the raw material is concerned. It is safer, however, not to

select an area for exploitation where seeding of the dominant species is expected within the next 20 years and where no other species is available to fill the gap.

Felling

The felling rotation varies with the species of bamboo from 3 to 7 years. It should obviously be so fixed as to ensure sustained and uninterrupted supplies of raw material.

As regards the correct system of felling bamboos, the view generally held is that clear-felling considerably weakens the reproductive power of the clump. Consequently it is desirable that a certain proportion of culms (say about 25 per cent including all young culms) should be left in each clump, so that a sufficient leaf area is available for the accumulation of nourishment by the root stock. Clear-felling, however, is much more economical than partial felling, and may be adopted in cases where large areas are available and sufficient time can be allowed for the full reproduction of the clumps. This period will be about the same as for regeneration from the seedling stage, so that the felling rotation in such cases should be fixed at from 6–10 years, according to the species of bamboo.

Extraction

A plentiful and reliable supply of labour should be available for the extraction of the bamboos from the forests.

Conversion into Pulp

Raw materials can be converted into pulp either by mechanical or chemical processes. The mechanical process consists in grinding the raw materials against rapidly revolving stones, whereby the fibres are torn apart by abrasion. The fibres are cut very short and contain all the constituents originally present in the raw material. Such pulp is used only for the manufacture of the cheapest kinds of papers, for which strength and durability are not essential desiderata. Soft light-coloured woods, mainly conifers, are suitable for this process. During recent years another mechanical process has been developed for the utilization of sawmill waste. In this process the material is exploded under high steam pressures (800–1,000 lb. per square inch). The pulp thus obtained is used for the manufacture of insulation and constructional boards. It has not been found practicable so far to apply mechanical processes to grasses or bamboos.

In the chemical process, as the name implies, chemicals are used to dissolve out from the raw material all constituents other than the fibrous cellulose. Pulps of varying degrees of purity and containing varying percentages of cellulose are thus obtained, depending on the severity of the chemical actions employed.

PAPER-MAKING

The process of manufacturing paper from bamboos and grasses briefly consists of the following operations:

Cleaning

The raw materials are freed from adhering dirt and cut into small lengths to facilitate subsequent chemical action during digestion. Bamboos are usually first crushed and then cut and disintegrated. *Sabai* grass is sometimes not cut but digested in whole culms.

Digestion

The disintegrated material is digested with chemicals at temperatures which vary with the nature of the materials and with the kind of pulp to be manufactured. Usually, temperatures higher than 162°C. are not employed. The chemicals dissolve out about 55–65 per cent of the material and leave behind mostly fibrous cellulose, which is what is known as pulp.

The two principal chemical processes employed for digestion are (1) the soda or sulphate process, and (2) the sulphite process. Investigations carried out at the Forest Research Institute have established (*a*) that considerable economies are effected if the digestion of grass or bamboo by the soda or sulphate process is carried out fractionally in two stages instead of in one stage, as has hitherto been the practice in mills, and (*b*) that the sulphate process is more economical than the soda process, both as regards consumption of chemicals and yield of pulp.

In the soda process, the active chemical used is caustic soda, and in the sulphate process a mixture of caustic soda and sodium sulphide. In either process about 75–80 per cent of the alkali used is recoverable from the spent digestion liquors as sodium carbonate. This is reconverted into caustic soda by the action of quicklime. The balance of alkali (20–25 per cent) is made up by the addition of the requisite quantities of fresh sodium carbonate and lime in the soda process, and of sodium sulphate in the sulphate process. Sodium sulphate is reduced to sodium sulphide in special smelting furnaces by carbon present in the recovered soda ash. Chemicals required for digestion by the soda process are, therefore, sodium carbonate and lime, and by the sulphate process, sodium sulphate, and lime.

For the production of one ton of bleached pulp from *sabai* grass or bamboo the average quantities of chemicals required for digestion by the sulphate process, assuming 75 per cent soda recovery and the proportion of caustic soda to sodium sulphide used as 3 to 1, are as follows:—

	Sabai grass	Bamboo
Lime (80% CaO)	$5\frac{3}{4}$ cwt.	$7\frac{1}{4}$ cwt.
Sodium sulphate (95% purity)	$3\frac{3}{4}$ cwt.	5 cwt.

In the sulphite process the active chemicals used are calcium or magnesium bisulphite and free sulphurous acid. Digestion is carried out in one stage only. A commercial process for the recovery of chemicals from the spent digestion liquor has not yet been developed. The process is used for pulping bamboo and not *sabai* grass. Chemicals required for digestion by this process are: (1) sulphur, and (2) limestone or dolomite.

Bleaching

Pulp obtained by any one of the above processes is washed with pure clean water and then bleached with bleaching powder or other chlorine compounds. The quantities of standard bleaching powder required for the production of one ton of bleached pulp from *sabai* grass and bamboo are about $1\frac{1}{3}$ cwt. and $2\frac{1}{3}$ cwt. respectively.

Beating

The next operation, which is the beginning of paper-making proper, is the treatment of the pulp in the beater with a view to separate out the fibres and beat them mechanically so as to impart to them the necessary felting power on the paper machine. During the process of beating the fibres are sized also, i.e. they are coated with a precipitate of rosin and aluminium compounds in order to make the paper ink-resistant. Loading material, usually china clay, is also added to the pulp in the beater. The particles of clay serve to fill up the interspaces between the fibres in the sheet and thus help in obtaining a homogeneous and smooth sheet of paper. When coloured papers are required to be produced, the necessary dyes are also added to the pulp in the beater. The process of beating is very intricate and requires considerable skill. The qualities required in a sheet of paper are to a large extent imparted to the fibres by manipulating the process of beating the pulp in the beater: in fact the saying is, 'Paper is made in the beater'.

Felting

Large quantities of water are next added to the beaten pulp so that the individual fibres are freely suspended in it. This water with the fibres suspended in it, after passing over sand traps and through fine strainers, flows over an endless wire cloth of fine mesh, moving in a frame which is given a gentle horizontal shake. Part of the water falls through the wire cloth by gravity and part

is drawn out by suction. During this process the fibres felt and interlace with each other and gradually form a continuous web which settles down on the wire. This wet web of paper then leaves the wire cloth and is carried forward by woollen felts between two or three pairs of rollers which press out more water from the pulp web. The remaining water is driven out by heat, by leading the continuous web of paper around steam-heated cylinders. The web is then quite dry and is passed through a stack of calender rolls to give it a smooth and polished surface. It is then either rolled or cut into sheets of the required size.

Manufacturing site

The standard ratios of yield of bleached paper generally accepted in the trade are 38 per cent for bamboo and 35 per cent for *sabai* grass. Therefore, on the average nearly 52 cwt. of bamboo or 57 cwt. of *sabai* grass are required for the production of one ton of bleached paper. In addition to the primary raw materials the requirements of chemicals (lime, sodium sulphate, bleaching powder, rosin, alum, clay, etc.), coal, lubricating oils and machine accessories, etc., necessary for the manufacture of a ton of paper, are approximately 5-6 tons. Including the finished product, the total quantities of materials which require transportation in connexion with the manufacture of one ton of paper consequently come to about 8½-9½ tons. Adequate and cheap facilities for transport are, therefore, of very great importance in the selection of a site for paper manufacture, particularly as complicated and heavy machinery, often weighing thousands of tons, is required for the purpose.

Other factors of importance in the selection of a manufacturing site are:—

(1) Proximity to the sources of raw material and coal. The quantities of these two items alone constitute more than 75 per cent of the total materials required for the manufacture of paper. The site should, therefore, be selected in a place where the combined transport charge for coal and raw material is as low as possible.

(2) Plentiful supplies of fresh, clear, soft water. Roughly 60,000–150,000 gallons of water, depending on the quality of paper manufactured, are required for the production of one ton of paper.

(3) Plentiful supply of reliable labour.

(4) Suitable means for the disposal of waste.

Ordinarily it would be economic if mills for the production of pulp were erected near the source of raw materials, and paper mills in the neighbourhood of coal-fields and the principal markets for paper. In the circumstances obtaining in India at present, this does not appear to be feasible. Firstly, the demand for pulp is not sufficiently large to give the pulp industry the advantage of mass-production, and secondly, cheap sources of power do not exist within easy reach

of localities near forest areas where pulp factories can possibly be erected. Considering, however, (1) that the consumption of paper in this country is growing fast, (2) that the pulpwood resources in Western countries, which are economically exploitable, are believed to be hardly adequate to meet in the near future the enormous demands made upon them and that, therefore, some other suitable materials have to be found which can supplement these resources, and (3) that hydro-electric power projects are being developed in several provinces, it appears very probable that mass-production of pulp, both mechanical and chemical, from bamboos and Himalayan woods may soon become a practical proposition.

Classes of papers

The numerous types and classes of papers and boards manufactured and put on the market may be classified into ten main groups, viz.: (1) Writings, (2) Printings, (3) News, (4) Tissues, (5) Wrappings, (6) Covers, (7) Absorbents, (8) Cardboards, (9) Pasted and other boards, and (10) Building papers. Each of these groups may further be sub-divided, e.g. Writings include bonds, ledgers, linens, drawing and safety papers; Printings include coated papers, Bible papers, book papers; Tissues include glassine and cigarette papers; Absorbents include blotting papers, filter papers, and so on. The peculiar characteristics of each class of paper depend to a great extent, though not entirely, on the purity, length, and strength of the individual fibres which go to make it. Since the fibres derived from different raw materials possess different characteristics, the art of paper-making requires considerable skill in judiciously selecting the right fibres and in blending fibres from different materials so as to produce papers with the requisite characteristics. For instance, for the production of the limited types of papers produced in this country, *sabai* grass pulp is blended variously with imported wood pulp, cotton, hemp, and jute pulp, and bamboo pulp is usually blended with wood and grass pulp.

Costs of manufacture

It will thus be seen that the requirements of raw materials for a paper mill depend (1) on the output of the mill, (2) the qualities of papers to be made, (3) the average proportions in which the raw materials are used for the production of different qualities of papers, and (4) the average percentage yields of pulp from the various raw materials. For instance, for the production of 4,000 tons of paper, which is about the smallest economic unit for a paper mill in this country, the annual requirements of bamboos and *sabai* grass will be approximately 7,300 and 3,400 tons respectively, on the assumption that these are the only two materials used and in the proportion of 70 and 30 per cent respectively.

It has been mentioned above that the price of a raw material delivered at mill site should be such as the industry can bear. It appears from a number of surveys carried out during recent years that it should be possible to extract bamboo and supply it to a mill at about Rs18 per ton. At this price it is estimated that it is possible to use bamboo for the production of a large variety of papers at competitive prices. For this cost of bamboo, the maximum cost of *sabai* grass should not be more than about Rs24 per ton, if pulp is to be made from it at a competitive price.

The total consumption of paper and boards in this country was estimated to be approximately 154,000 tons in 1928-9, giving a consumption of about 1 lb. per head per year. In the United States of America the *per capita* consumption of paper is over 200 lb. With the growth of literacy and the rise in the standard of living, the consumption of paper and boards in India bids fair to increase considerably in the future. In fact in the last ten years, i.e. from 1928-9 to 1938-9, the consumption of paper in this country increased by nearly 39 per cent.

Prospects

Besides papers and boards, there are a number of other commodities, e.g. artificial silk, cinema films, lacquers, varnishes, celluloid products, paper textiles and articles, etc., the consumption of which is rapidly increasing in this country. These commodities are assuming greater and greater importance in the economy of modern life in all civilized countries. As chemical pulp or cellulose is the starting material for the manufacture of these commodities and as India abounds in raw materials for the production of cellulose, the field for the development of paper and cellulose industries, not only to satisfy home requirements but also for an export trade, is very vast indeed. It is, therefore, expected that private enterprise, aided by research for which Government have provided facilities at the Forest Research Institute at Dehra Dun, will not be slow to seize the opportunity of exploiting India's vast natural resources and thus help in the economic and industrial regeneration of this country.

XXIII

GRAZING AND GRASS-CUTTING

GRAZING; dangers arising from forest grazing—advantages of forest grazing—factors on which the amount of damage done by grazing depends—regulation of grazing. GRASS-CUTTING; hay.

The utilization of grass is, when considered from the point of view of grazing and fodder, one of the most important factors in maintaining the agricultural prosperity of India. Under ordinary circumstances grazing is most injurious to forests, but so essential is it to the welfare and even to the existence of the agricultural population that it has to be permitted in spite of the obvious harm it may be causing. The subject will be dealt with separately under the two heads, grazing and grass-cutting.

GRAZING

Dangers arising from forest grazing

Grazing has the following injurious effects on a forest:—

(1) Seedlings and saplings are browsed down.
(2) Young growth is crushed by trampling.
(3) The removal of grass and other vegetation exposes the soil and removes manurial matter.
(4) Heavy grazing and browsing may so reduce the protection to soil afforded by grass and shrubs that erosion will be started. This is often the greatest harm caused by grazing in this country.

Advantages of forest grazing

The disadvantages of grazing far outweigh the advantages. Some benefit to the forest may, however, accrue where grazing is controlled. Where grass and herb growth is excessive, grazing may lessen the herbaceous covering and help natural regeneration to become established. In the same way fire hazard may be reduced.

By allowing grazing before the seed fall in a good seed year, especially in coniferous forests, natural regeneration may be stimulated by the wounding of the soil and disturbance of the needle layer by the animals' feet. In the teak

forests of Burma, grazing by elephants may do a great deal of good by breaking down bamboos and promoting the natural regeneration of teak.

Factors on which the amount of damage done by grazing depends

(1) **Kind of cattle.**—Speaking generally, grazing includes browsing, though strictly interpreted browsing implies the eating of vegetation other than grass and herbs, and is therefore generally more harmful in forestry than grazing proper.

Camels and goats are the most destructive animals; the former nibble off the shoots of trees and young growth and their great height enables them to do considerable damage. Goats, as they pass through the forests in dense herds, eat everything that comes in their way, and by standing up on their hind legs can reach to quite a height. Coniferous forests in the mountain areas and scrub forests in the low hills suffer severely in every way from the effects of goat grazing. Sheep are less destructive, as they prefer grass whenever they can get it. The damage done by buffaloes is enhanced by the crushing and trampling of young growth. Cows and bullocks are, for their size, probably the least harmful of all grazing animals as they prefer grass, but owing to their great numbers they are the chief source of damage in the plains. Wild elephants sometimes break down poles and saplings in regeneration areas and plantations, and they sometimes do serious damage to bamboos in places where they are of value. Other animals such as deer can also do considerable harm if their numbers are allowed to become excessive, but the damage done by such animals is small when compared with the damage done by the millions of cattle which graze in forest areas throughout India.

(2) **Season of grazing.**—The season in which grazing is most required and in which most harm is done varies locally. In many parts of the country, the dry season is the season of heavy forest grazing owing to the scarcity of fodder outside. In many rice-growing districts, forest grazing is required in the rains, as the cattle cannot be admitted into the fields while the rice crop is on the ground. In the hills, the incidence of grazing in the lower forests is greatly increased during the winter, as the higher forests and alpine pastures are then under snow. Most damage is, however, done in the hot season when the grass and herbage has dried up. Grazing in the dry season also leads to danger from fire, and it may be necessary to close forests during the fire season. Bamboos are very vulnerable during the rains as this is the time that the new shoots appear.

(3) **The number of cattle per acre.**— The greater the number of cattle admitted per acre, the greater will be the damage done to the forest. Wherever

possible, it is advisable to fix the maximum number of animals which may be allowed to graze over a given area. It is not possible to lay down a general figure, as the number must depend on such local conditions as the type of forest, and the contending requirements of forest preservation and agriculture. The best idea can probably be obtained by observing the effect on the forest of grazing a given number of animals, and then fixing the number in accordance with the degree of protection considered necessary. In India, for oxen, ponies, and mules, the figure would probably be not less than 1 acre per head of cattle, and for sheep and goats not more than 3 animals per acre.

Regulation of grazing

In order to minimize the injurious effects of grazing, it is necessary to control it carefully. The chief measures that can be taken are as follows:—

(1) The management of the forest must be so ordered that forests coming under regeneration can be closed to grazing long enough to allow the regeneration to become fully established. The conditions of regeneration in forests under selection management must be carefully studied with a view to ascertaining whether a scheme of rational closures is necessary or not.

(2) Grazing may be allowed in the forests for a limited period in the year.

(3) The herds should be under the charge of a responsible herdsman, who should not have more cattle under his charge than he can control. Cattle should be grazed over the whole open area and not kept too much in one part. In some localities each grazier has to wear a brassard on his arm showing he has authority to graze.

(4) Cattle may be provided with bells so that straying animals may be detected.

(5) The number of cattle per acre may be limited to prevent over-grazing. In forests where rights are admitted, the maximum number is usually fixed under the forest settlement. The issue of brass number tags to be fixed round the necks of the animals is a useful means of checking the numbers.

(6) Grazing fees may be levied.

(7) Grazing may be controlled by forming a grazing working-circle under the working plan.

(8) Adequate fencing must be made round areas closed to grazing, and if necessary notices should be posted.

Grass-cutting

The cutting of grass in a forest is far less harmful in its effects than grazing, in fact considerable benefit may be derived from it.

As in the case of grazing, a certain amount of manurial matter is removed from the ground, and the soil may be subjected to increased exposure, while tree seedlings are liable to be cut. On the other hand, the removal of grass greatly reduces the chances and severity of fire, and may secure more favourable conditions for the establishment of natural regeneration. Where grass-cutting and grazing are extensive, it is customary for villagers to burn the grass areas every winter in order to stimulate fresh growth. This practice is objectionable in the hills as it tends to increase the chances of erosion, but it is often claimed as a right and if the claim is upheld it is difficult to stop. All such burning should, however, be done under supervision, and preferably during the season of the winter rains, so that the chances of the fire getting out of control and entering the forest are diminished. This practice effectively inhibits any natural tendency of the forests to extend. On the other hand, the departmental burning of areas under canopied crops, such as *Pinus longifolia,* is an established feature of the management of some species. This operation has the dual advantage of decreasing the danger of fire by removing the layer of needles, while it stimulates the subsequent grass growth and so keeps the villagers contented.

Hay

The growing and making of hay is ordinarily outside the province of forestry, but in cases of famine the Forest Department may be called upon to take part in relief measures by supplying hay, so the subject is briefly mentioned here.

The best hay is produced when grass is cut immediately after it flowers. If cut after fruiting it is harder, more fibrous, and less nourishing, as much of the food material has been used up in the formation of the seeds. Grass for hay should always be cut in dry weather and should be spread out at once to dry. In the evening it should be collected in heaps before the dew falls. The following day it should be spread out again and tossed with wooden forks, and then carted and stacked if properly dry. If not properly dry, the process should be repeated daily until it is dry. Hay for storage should be built up in stacks. These may be either round with a conical roof, or house-shaped with a pent roof and projecting eaves. The roof should be thatched if the stack is to stand for some time. The stack should be built on a well-drained site and should if possible rest on a good layer of cinders or stones, or on a wooden platform raised off the ground, and should be trenched round. In order to reduce its bulk for transport and if the output justifies the expense, hay may be pressed into bales by special presses worked by hand or mechanical means.

Grass can also be stored for years in silos. In this case the grass must be cut and put into the silo while it is green. The silo, which is nothing more than an open pit, is then covered over and the grass ferments into a damp mass which is known as silage. Silage is an excellent cattle-food, and is often preferred by cattle and horses after they have got used to it. The use of silos is extending in India, and is a very suitable method of storage for this country, as the large quantities of green grass available in the monsoon season can thereby be stored for use in other seasons when fodder is scarce.

A KEY FOR THE IDENTIFICATION OF 30 IMPORTANT INDIAN TIMBERS

A KEY FOR THE IDENTIFICATION OF 30 IMPORTANT INDIAN TIMBERS

The following key mainly refers to the anatomical structure visible on the end surface of a piece of wood. Whenever other surfaces are taken into consideration they have been specifically mentioned.

For field identification two things are required; a good steel knife which must be kept *very sharp*, and a hand lens, magnifying 10–12 times. Such lenses can be obtained from any scientific-instrument dealer. In addition to these, a small chisel and a hammer are often useful, especially when one wants to identify big pieces of timber which cannot be lifted easily. A small piece can be cut off with the chisel and hammer and examined according to the method of procedure given below.

Make a sharp cut on the end surface. Hold the lens close to the eye and gradually bring the object towards the lens till its structure is clearly visible. As a rule, moistening improves the cut surface by bringing out the structure in detail, but there are exceptions to this. Both ways should, therefore, be tried to get the best definition.

In the key, timbers have been grouped according to their structural features, and every group has a duplicate number on the left hand side, showing alternative characteristics. The numbers on the right hand side indicate where further divisional characteristics are to be sought. For example, a timber on examination appears to be porous. This leads us to number 6. If it is ring-porous, it will take us to number 7. On further examination, if it shows ripple marks, then it must be one of those under numbers 8 or 9. If no ripple marks are present, then it goes on to number 10, and the search is continued in this fashion till the timber has been traced.

It will be noticed that certain timbers have been mentioned in the key more than once. This is due to the fact that they show a structure which is on the border-line of two alternatives and may be classified under either group. On account of the difference in personal interpretation, it has been thought advisable to place them under the two alternatives. Whenever in doubt, the best thing to do is to try both alternatives.

KEY

1. Wood non-porous **2**

1. Wood porous **6**

2. Resin canals present, mostly scattered **3**

2. Resin canals usually absent, if present grouped in tangential bands **5**

3. Resin canals fairly large, distinctly visible to the eye, rather numerous. Wood moderately heavy **4**

3. Resin canals minute, not visible to the eye, scanty. Wood moderately light, lustrous. SPRUCE, *Picea morinda.*

4. Wood yellow to pale reddish brown. Transition from spring to summer wood abrupt. CHIR, *Pinus longifolia.*

4. Wood with a pinkish tinge. Transition from spring to summer wood gradual. BLUE PINE, *Pinus excelsa.*

5. Wood with characteristic odour. Resin canals occasionally in short concentric bands. DEODAR, *Cedrus deodara.*

5. Wood without any characteristic odour or taste. Resin canals absent. FIR, *Abies pindrow.*

6. Wood ring-porous or semi-ring-porous **7**

6. Wood diffuse-porous **14**

7. Ripple marks present, very distinct on the tangential surface .. **8**

7. Ripple marks absent **10**

8. Heartwood golden yellow to golden brown, often streaked with darker bands. ANDAMAN PADAUK, *Pterocarpus dalbergioides* (off colour).

8. Heartwood reddish brown to dark red **9**

9. Heartwood bright red, often streaked with black. ANDAMAN PADAUK, *Pterocarpus dalbergioides.*

9. Heartwood brick red, rather dull in appearance. BURMA PADAUK, *Pterocarpus macrocarpus.*

10. Pores in radial or obliquely radial groups. Rays very broad and conspicuous, forming prominent ray flecks on the radial surface. OAK, *Quercus incana.*

10. Pores not in radial groups. Rays minute to fairly broad, scarcely forming prominent ray flecks on the radial surface **11**

11. Parenchyma round the late pores, often forming wavy tangential bands. Rays not visible to the naked eye. Wood light red to bright reddish yellow. JARUL, *Lagerstroemia flos-reginae.*

11. Parenchyma bands seldom connecting the late pores. Rays distinctly visible to the eye **12**

12. Tyloses absent, vessels with dark gummy deposits. Wood brick red to dark reddish brown. TOON, *Cedrela toona.*

12. Tyloses present, wood not red **13**

13. Heartwood dark golden yellow to brown. Vessels occasionally filled with white gummy deposits. Wood rather dull. TEAK, *Tectona grandis.*

13. Heartwood yellowish to greyish white. Wood lustrous. GAMARI, *Gmelina arborea.*

14. Ripple marks present **15**

14. Ripple marks absent **17**

15. Heartwood golden yellow to golden brown, often streaked with darker bands. ANDAMAN PADAUK, *Pterocarpus dalbergioides* (off colour).

15. Heartwood reddish brown to dark red **16**

16. Heartwood bright red, often streaked with black. ANDAMAN PADAUK, *Pterocarpus dalbergioides.*

16. Heartwood brick red, rather dull in appearance. BURMA PADAUK, *Pterocarpus macrocarpus.*

17. Resin canals present, often containing whitish deposit **18**

17. Resin canals absent **20**

18. Resin canals mostly in short bands or groups. Wood moderately hard to hard, somewhat coarse-textured. GURJUN, HOLLONG, or *ENG*, *Dipterocarpus* spp.

18. Resin canals usually in long concentric bands **19**

19. Tyloses completely filling up the pores of the heartwood. Wood dull brown, heavy to very heavy. SAL, *Shorea robusta.*

19. Tyloses partly filling up the pores of the heartwood. Wood with a distinct yellowish tinge, moderately heavy to heavy. ANDAMAN THINGAN, *Hopea odorata.*

20. Pores fairly large, distinct to the naked eye **21**

20. Pores minute, individually indistinct to the naked eye .. **37**

21. Pores in radial or obliquely radial groups **22**

21. Pores rather irregularly arranged **24**

22. Rays very broad and conspicuous, forming ray flecks on the radial surface. Parenchyma in fine, wavy tangential bands. OAK, *Quercus incana.*

22. Rays very fine and inconspicuous **23**

23. Tangential bands of parenchyma more or less equidistant. Wood brick red, very heavy, extremely hard. MESUA, *Mesua ferrea.*

23. Tangential bands of parenchyma irregularly distributed, often ending abruptly. Wood pale brownish red with dark-coloured bands, moderately heavy to heavy, moderately hard. POON, *Calophyllum* spp.

24. Rays individually visible to the naked eye **25**

24. Rays individually indistinct to the naked eye **31**

25. Terminal or initial bands of parenchyma present **26**

25. Terminal or initial bands of parenchyma absent **30**

26. Parenchyma in fine tangential bands forming reticulum with the wood rays. Wood very light. SEMUL, *Bombax malabaricum.*

26. Parenchyma not forming reticulum with wood rays **27**

27. Wood soft to moderately soft **28**

27. Wood moderately hard to very hard **29**

28. Parenchyma forming conspicuous eyelets round the pores. Tyloses absent. Wood dark brown with black and grey streaks. KOKKO, *Albizzia lebbek.*

28. Parenchyma not conspicuous round the pores. Tyloses abundant. Wood yellowish to greyish white. GAMARI, *Gmelina arborea.*

29. Wood pink to dark red, very hard. Pores often containing blackish gum. BABUL, *Acacia arabica.**

29. Wood light reddish brown, moderately hard. Pores often containing whitish gum. DHAMAN, *Grewia tiliaefolia.*

30. Wood deep brown often with pinkish tinge, very hard, very heavy. Parenchyma diffuse. SUNDRI, *Heritiera minor.*

30. Wood light greenish brown, moderately hard, moderately heavy. SALAI, *Boswellia serrata.*

31. Rays (with a hand lens) irregularly spaced. Parenchyma forming conspicuous eyelets round the pores. Wood dark brown with black and grey streaks. KOKKO, *Albizzia lebbek.*

31. Rays (with a hand lens) equidistant, rather fine **32**

32. Wood moderately heavy, moderately hard; dark brick red, sometimes exuding sticky gum. Parenchyma in prominent straight tangential bands. PINEY, *Hardwickia pinnata.*

32. Wood heavy to very heavy, hard to very hard **33**

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* Terminal or initial bands of parenchyma may be overlooked on casual examination but they are always present.

33. Parenchyma mostly in long wavy tangential bands, often connecting pores **34**

33. Parenchyma mostly in thin bands round the pores, seldom in wavy tangential bands **36**

34. Terminal or initial bands of parenchyma distinct. Wood greyish brown to dark brown, hard to very hard. LAUREL, *Terminalia tomentosa*.

34. Terminal or initial bands of parenchyma not distinguishable .. **35**

35. Wood rose-purple to dark brown with a characteristic odour. INDIAN ROSEWOOD, *Dalbergia latifolia*.

35. Wood golden brown to dark brown without any characteristic odour. SISSOO, *Dalbergia sissoo*.

36. Wood yellowish grey, often with a greenish tinge. YON, *Anogeissus acuminata*.

36. Wood dark reddish brown, often with an oily appearance. *PYINKADO*, *Xylia dolabriformis*.

37. Wood moderately hard to hard, distinctly yellow. Parenchyma diffuse. HALDU, *Adina cordifolia*.

37. Wood hard to very hard; yellowish grey, often with a greenish tinge. Parenchyma in thin bands round the pores. YON, *Anogeissus acuminata*.

APPENDIXES

I

MARKING RULES

Classification of trees into sound, hollow-fit, and hollow-unfit

(A) **Sound.**—Trees (other than those under (B) i) whose merchantable boles in the opinion of the marking officer are quite sound. No tree should be marked as sound unless, in the opinion of the marking officer, the whole of its merchantable bole is quite sound.

(B) **Hollow-fit.**—i. Sound trees whose boles are very short or misshapen.
ii. Unsound trees whose merchantable boles in the opinion of the marking officer contain any sound timber fit for sawing.

(C) **Hollow-unfit.**—Unsound trees whose merchantable boles in the opinion of the marking officer contain no sound timber fit for sawing.

NOTES:

(1) Only the merchantable bole is to be considered. A tree whose branches contain timber fit for sawing but whose bole contains no timber fit for sawing will be classified as hollow-unfit.

(2) Only timber fit for sawing is to be considered. A tree whose merchantable bole contains timber fit for *tors*, but not for sawing, will be classified as hollow-unfit.

Marking instructions

(A) Every tree marked must have two blazes, an upper and a lower, and these blazes must be of a size sufficient to make them easily recognizable as marking blazes.

(B) Whenever a tree is selected for lopping, in order to avoid damage in felling, an L should be placed in coal-tar on the upper blaze. No other mark should ever be placed on the upper blaze except as noted in (C) below.

(C) The hammer mark will be placed on the lower blaze. In places where white ants are prevalent and where the hammer mark is in consequence apt to disappear from the lower blaze before the following season, it may be advisable to put a dab of coal-tar on the hammer mark to preserve it, or even to put a hammer mark on the upper blaze as well. The hammer mark must, however,

always be placed on the lower blaze. In addition to this, a serial number whenever placed will also be placed on the lower blaze.

In the case of sal the following instructions are issued:—

> Every sal tree above 12″ diameter will have a serial number placed on the lower blaze. In the case of sound trees this number will be stamped with an iron die. On hollow-fit and hollow-unfit trees, it will be painted with coal-tar, the letter U being added in the case of unfit trees. The series of numbers in the case of hollow-fit and hollow-unfit will be only one, but this will be different from the series given to sound trees. Similar serial numbering can be applied to any other species if desired.

(D) In actual markings in the forest, trees must be called out by the hammer man and by no one else.

(E) The height of all sal trees above 16″ diameter should be recorded.

II

EXAMPLE OF UNITED PROVINCES' TREE MARKING REGISTER

BOOK NO. 7 PAGE 48

Dehra Dun Division, *Lachiwala* Range, Compartment No. *Phandowala* 3a

Sal conversion. Working Circle *Eastern* Felling Series Coupe No. *Plot I*

Species		Diameter Classes: 8" to 12"	12" to 16": Sound	12" to 16": Unsound Fit	12" to 16": Unsound Unfit	16" to 20": Sound	16" to 20": Unsound Fit	16" to 20": Unsound Unfit	20" to 24": Sound	20" to 24": Unsound Fit	20" to 24": Unsound Unfit	24" and over: Sound	24" and over: Unsound Fit	24" and over: Unsound Unfit	*Trees to be lopped*
Sal, green		𝍸 𝍸 𝍸 𝍸 𝍸 | **26**	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 ||| **38**	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 || **42**	||| **3**	10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 26, 27, 28, 29. 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 41 **28**	35, 37, 41, 44, 48, 50, 51, 52, 53, 54, 55, 56, 57, 59, 60, 62, 63, 64, 65, 66, 67, 70, 71, 72, 75, 78, 80, 81, 88, 89, 92, 93, 94, 95, 96, 97, 98, 101, 102, 103, 107, 108, 110, 111, 113, 114, 115, **47**		22, 24, 25, 40, 42 **5**	36, 38, 39, 40, 42, 45, 46, 47, 58, 68, 69, 74, 76, 79, 82, 84, 85, 86, 87, 99, 100, 104, 106, 109, 112 **25**	83 **1**		43, 49, 90, 91, 105 **5**		𝍸 ||| **193**
Sal, dry		𝍸 | **6**		| **1**	| **1**		73, 77 **2**			61 **1**					
Sain							| **1**						| **1**		
Dhauri		𝍸 | **6**		| **1**											
Bahera			| **1**			||| **3**	| **1**			||| **3**					
Haldu										| **1**					
Kokat			| **1**	|| **2**		|| **2**	||| **3**								

Date.................................... *Marking Officer*....................................

Reverse of previous page

Heights in feet							
Sound trees			Hollow-fit trees				
16″–20″	20″–24″	24″ and over	16″–20″		20″–24″	24″ and over
10 = 85	22 = 87		35 = 77	95 = 76	36 = 78	43 = 87
—	24 = 94		—	—	38 = 80	49 = 88
11 = 85	25 = 92		37 = 75	96 = 74	39 = 85	90 = 90
12 = 90	40 = 90		41 = 75	97 = 77	40 = 80	91 = 78
13 = 74	42 = 89		44 = 88	98 = 82	42 = 84	105 = 82
14 = 92			48 = 69	101 = 75	45 = 76	—
15 = 80			50 = 78	102 = 84	—	
16 = 94			51 = 75	103 = 75	46 = 78	
17 = 84			52 = 75	107 = 80	47 = 71	
18 = 80			53 = 78	108 = 70	58 = 72	
19 = 83			54 = 72	110 = 79	61 = 72	
—			55 = 64	111 = 78	68 = 80	
20 = 78			—	113 = 75	69 = 75	
21 = 92			56 = 70	114 = 62	74 = 74	
23 = 80			57 = 80	115 = 82	76 = 84	
26 = 81			59 = 69	—	79 = 71	
27 = 78			60 = 73		82 = 83	
28 = 82			62 = 84		84 = 80	
29 = 83			63 = 90		85 = 72	
—			64 = 74		—	
30 = 88			65 = 72		86 = 72	
31 = 80			—		87 = 83	
32 = 80			66 = 80		99 = 78	
33 = 88			67 = 90		100 = 86	
34 = 80			70 = 75		104 = 86	
35 = 82			71 = 60		106 = 78	
36 = 80			72 = 78		109 = 80	
37 = 80			73 = 70		112 = 72	
38 = 75			75 = 79			
39 = 80			—			
—			77 = 80			
41 = 83			78 = 76			
			80 = 80			
			81 = 75			
			88 = 80			
			89 = 72			
			92 = 85			
			93 = 82			
			94 = 71			

III

ANNUAL SALE NOTICE FOR TIMBER AND OTHER FOREST PRODUCE OF THE DEHRA DUN FOREST DIVISION FOR THE YEAR 1935-6

Timber and other forest produce as shown in the sale lists hereto attached will be put up to auction on 19th and 20th August, 1935, at the Divisional Forest Office, Dehra Dun, at 10-30 A.M. on each day.

PART I

Rules for sale

1. The Divisional Forest Officer is endeavouring to obtain orders for the supply of sal sleepers to railways, through the Conservator of Forests, Western Circle. If a supply can be arranged the number of sleepers will be distributed amongst timber lots, and specifications and passing arrangements will be intimated later.

2. All lots will be on lump sum sale.

3. The Divisional Forest Officer accepts no responsibility as regards outturn of timber, number or classification of trees (except as laid down in rule 5 below) or in any other respect and will not consider subsequent representations of possible alleged losses. Purchasers should, therefore, weigh the consequences of excessive bids.

4. The Forest Department disclaims any liability in the cases of trees marked when green, turning out dry in the year of felling.

THE NUMBER AND SOUNDNESS OF TREES ARE NOT GUARANTEED NOR THE ALLOTMENT TO GREEN AND DRY.

5. In green timber lots if the buyer thinks the number of marked trees differs from that in the sale notice, he may have a recount on the following conditions if he makes a written application to the Divisional Forest Officer before 31st January, 1936:—

(*a*) For a recount of numbered sal trees of over 16″ diameter marked as sound he will deposit 5 per cent of the purchase price with his application with a minimum of Rs100. If the recount shows a deficit of more than 2 per cent the Divisional Forest Officer will remit a suitable proportion of the sale price and return the deposit.

If it shows 2 per cent deficit or less, no part of the sale price will be remitted and the deposit will be confiscated.

(*b*) For other trees, irrespective of species, he will deposit Rs250 with his application. If the recount shows a deficit of more than 10 per cent the Divisional Forest Officer will remit a suitable proportion of the sale price and return the deposit. If it shows 10 per cent or less, no part of the sale price will be remitted and the deposit will be confiscated.

N.B.—(1) The above rules only apply to first year green timber lots. The buyer cannot claim a recount or any rebate for second year fellings, dry timber fellings, wind fall sales, etc.

(2) If a buyer wants a recount of both numbered sound sal and other species he will deposit 5 per cent of the sale price and Rs250.

(3) It should be clearly understood that only the number is considered. Whether in fact the trees turn out sound or hollow is immaterial.

6. The Divisional Forest Officer does not bind himself to accept the highest or any bid.

7. Purchasers immediately on the fall of hammer will be required to sign agreement bonds and pay security deposits as under:

A minimum of 10 per cent of the sale value with a minimum total (subject to the discretion of the Divisional Forest Officer) of Rs50.

NOTE—(*a*) The above rates of security may be enhanced at the discretion of the Divisional Forest Officer to 20 per cent of the sale value.

(*b*) Government currency notes of over Rs100 will not be accepted as security unless they are of the Cawnpore Circle.

(*c*) Government promissory notes will be accepted at their current market value, under the rules laid down in the Civil Account Code, for part of the security deposit. But part of every security deposit should be in cash.

(*d*) Purchasers should note that the security for each contract should be deposited separately.

8. A purchaser required to sign the agreement under rule 7 will not ordinarily be permitted to transfer his right to do so to any other party, nor having signed the agreement will ordinarily be permitted to transfer the contract to any other party.

In special cases such transfers before or after signing the agreement may be permitted by an order in writing from the Divisional Forest Officer.

Sale will not be recorded in the name of more than one purchaser.

9. No sale will be considered valid until the security money has been paid and the agreement bond signed by the purchaser, and in the case of contracts which require the sanction of the Conservator, until his approval has been given.

10. Purchasers who are not residents in British territory may be required to pay the full contract price in addition to security money at the time of auction.

11. Payments of the purchase money will be by instalments as follows:—

(*a*) For sums not exceeding Rs100 on or before 15th October, 1935—The whole amount.

(*b*) For sums exceeding Rs100 but not exceeding Rs500:

On or before 15th October, 1935—Half of the total amount.
On or before 1st January, 1936—Half of the total amount.

(*c*) For sums exceeding Rs500:

On 1st December, 1935, or when work starts whichever is earlier—One-third of the total amount.
On or before 1st February, 1936—One-third of the total amount.
On or before 1st March, 1936—One-third of the total amount.

NOTE—In the case of sales arranged after the auction, the Divisional Forest Officer will fix the number, amount and dates of payment of instalments.

12. Revenue in sum of Rs50 and over must be paid by the purchaser into a Government treasury, unless otherwise ordered by the Divisional Forest Officer. In the former case a copy of the treasury challan should be sent without any delay to the Range Officer.

13. All produce will remain at the purchaser's risk from the date of sale.

14. The boundaries of the different lots will be shown to the purchaser by the Range Officer who will also give a written description of the same over his signature. The description of the boundaries will also be signed by the purchaser.

15. The Range Officer has at all times power to stop export if in his opinion the value of the material already exported is equal to the money paid, should the total sale price not have been paid.

16. Extraction of forest produce by right, concession, or privilege holders must not be interfered with by the purchaser and no charge will be levied by purchasers on material required for Government purposes.

17. Purchasers of fuel and thatching grass are warned that the grass in areas not protected from fire may be burnt departmentally at any season by order of the Range Officer. Purchasers will be warned whenever possible. The department is not responsible for loss through departmental or accidental firing.

18. Grass contracts are liable to immediate cancellation by the Divisional Forest Officer on repayment of all instalments and security deposits paid by the purchasers in the event of a fodder famine rendering such a course advisable.

19. Purchasers of minor produce shall be entitled to no compensation in the event of the free collection of products being ordered by Government.

20. In the contract-deed a date is given before which the first instalment must be paid and work must be begun in an earnest and thorough manner, failing which it will be open to the Divisional Forest Officer to quash the contract, confiscate all moneys paid in connexion with the contract, and resell the lot. The resignation or quashing of a contract will invariably entail the forfeiture of the security and the purchaser will be liable to make up the difference in sale price on the resale, or the whole amount if the lot is not resold.

21. Charcoal may only be made up to 15th February, 1936, and only in places pointed out by the Range Officer.

22. No contractor will be charged for any fire watcher up to the end of the normal period of his contract. If any contractor asks for an extension, and such is granted, he will have to pay for a fire watcher or fire watchers in accordance with the Divisional Forest Officer's decision regarding the number and rate of pay per mensem.

23. Copies of agreement bonds, rules for purchasers, local executive orders, and any further information required by intending purchasers may be obtained by written application to the undersigned at Dehra Dun.

PART II

Rules for export

1. The period of contract is shown against each lot separately in the sale list. Export from contractors' depots situated outside felling areas but inside reserved forests will be allowed up to 15th June, 1936. Ordinarily no extension of the period will be granted.

2. Purchasers are warned that motor roads must not be used by their cartmen. Purchasers will be held responsible for any damage done to motor roads by their cartmen.

3. Forest produce in transit may be conveyed along such roads only as the Divisional Forest Officer may direct. Only old cart tracks may be used inside the forest, unless special permission to the contrary has been obtained.

In areas marked for fellings in P.B. I and P.B. IX export by carts will be allowed only along cart tracks shown on the tracings enclosed with the agreement deeds. These cart tracks will be repaired by the Forest Department and will be pointed out in the forest by the Range Officer.

4. All forest produce in transit is liable to check at any time and at any place.

5. (*a*) No dragging by cattle will be allowed along any road at any time of the year, unless the express permission of the Divisional Forest Officer has been obtained in writing.

(*b*) Purchasers wishing to export their timber or other forest produce on camels will be required to deposit Rs50 as a security against illicit lopping by their camelmen.

6. Under the terms of the agreement deed all purchasers must issue ***rawanas*** to accompany all produce exported from their lots and they must send a copy of every ***rawana*** so issued to the Range Officer. The produce exported must be described in the ***rawana*** in such detail as to afford full proof that the produce exported is really that for which the ***rawana*** has been issued.

7. A separate ***rawana*** must be issued for each cart, and in the case of ponies, camels, bullocks, etc., for each batch. Any produce in transit found in excess of the quantity entered in the ***rawana*** will be seized and held pending the Divisional Forest Officer's orders.

8. No timber may be exported from the felling area unless it has been marked with a sale hammer, where a sale hammer is employed, and also with the contractor's registered hammer. Where the ***chauki*** system is in force the sale mark will be put on by the export ***muharrir*** employed at the ***chauki*** concerned. It should be noted very carefully that in any case the contractor's registered hammer must be put on before the timber leaves the contract area. Any piece of timber found in transit which has not been so marked will be seized and held pending the Divisional Forest Officer's orders.

9. *Rawana* books will be supplied by Range Officers to purchasers, on payment. Purchasers of these books may not resell them to other purchasers, nor may one book be split up for use in two lots or for two lines of export. A refund or the full sale price will be made on all unused books returned at the end of the working season. A purchaser's security money will not be returned until he has returned all unused, partly used or completely used ***rawana*** books to the Range Officer at the expiry of the export.

PART III

Rules for felling trees

1. (*a*) In felling areas the purchasers of standing trees may fell such trees only as have been marked with the Government hammer mark, an impression of which is given on each contract deed. Trees with blazes but no hammer marks will not be given to the purchasers as they are not included in the sale list. Even if such trees have serial numbers they are not to be felled till the Divisional Forest Officer has passed orders.

(*b*) Purchasers of standing trees in P.B. I and P.B. IX areas shall not fell any marked tree unless it has been previously lopped by the Forest Department.

2. Purchasers shall be considered responsible for any illicit felling within the areas for which they hold contract.

3. Careless felling resulting in damaging or knocking down standing unsold trees of any class may be punished by fine at the discretion of the Divisional Forest Officer and the conversion and export of any such trees by the purchaser concerned is absolutely prohibited.

NOTE—For the purpose of judging whether or not a purchaser is to be held responsible for any such damage done, the axe and saw cuts will be inspected by the Range Officer; if the slope is in the direction in which the tree should have been felled, the purchaser will usually be considered to have done his best to avoid the damage. If the slope of the cuts is in the direction in which the tree fell and this is not considered to be the best direction the purchaser will be held responsible.

PART IV

General

1. On no consideration whatsoever may money, valuables or other property be deposited with Range Officers, forest guards, *muharrirs* or other Government servants for safe keeping, and the Divisional Forest Officer will not undertake to make any inquiry into alleged thefts or losses from forest *chaukis*.

2. The giving of any gratification to a forest subordinate is strictly prohibited; any such case coming to light will be severely dealt with.

3. Any case of a forest guard or other forest subordinate demanding or accepting toll from carters or camelmen, should be immediately reported to the Divisional Forest Officer.

4. Villagers and others are entitled to cut grass free of charge in areas open to grazing for their cattle.

5. Purchasers of green timber lots must undertake to saw timber for Government purposes if ordered to do so by the Divisional Forest Officer at any time within the period of the working season, i.e. 15th November to 31st March. For sawing such timber the purchasers will be paid at a rate per cu. ft. to be fixed by the Divisional Forest Officer. In fixing this rate, the Divisional Forest Officer will endeavour to fix the current market rate of the year, but his decision on the subject shall be final.

DEHRA DUN: *Divisional Forest Officer,*
14th June, 1935. *Dehra Dun Forest Division.*

IV

FORM OF CONTRACT FOR SALE OF TIMBER ON LUMP SUM

THIS INDENTURE made the————————day of ————————— between the Secretary of State for India in Council (hereinafter called the 'seller') of the one part, AND ——————————————————— son of————————————————————caste—————————————— resident of————————————in the district of—————————————————— (hereinafter called the 'buyer') of the other part witnesseth as follows:—

1. The seller, in consideration of the payment by the buyer as hereinafter provided of the price of Rs——————————————(Rupees—————— ———————————), hereby sells to the buyer, subject to the conditions hereinafter appearing and to the conditions published in the sale notice, a copy of which is hereto attached, the following forest produce:

(Description of forest produce sold and limits of area)

A facsimile of the Government hammer mark with which the trees sold under this indenture are marked is shown below:—

(Facsimile of hammer mark)

The bark of the trees herein described is not included in the sale under this indenture, and the Divisional Forest Officer shall be at liberty to dispose of it as he may think fit, subject to the proviso that no delay or inconvenience shall thereby be caused to the buyer in the felling or conversion or removal of the timber purchased by him. Forest produce within the limits of the area above specified required for the holders of lawful rights, privileges, or concessions, and fallen fuel required by wayfarers and others for immediate use (but not for removal to a distance), are not included in the sale under this indenture.

2. (*a*) The buyer shall pay the said sum of Rs————————
(Rupees————————————————————)
by the following instalments, namely:—

Payments of and penalties for non-payment of instalments, fines, etc.

Rs————on or before the————day of————19 .
Rs————on or before the————day of————19 .
Rs————on or before the————day of————19 .
Rs————on or before the————day of————19 .

All payments by the buyer shall be made into such Government treasury, or in such manner as the Divisional Forest Officer (hereinafter called the 'Forest Officer') shall direct.

(*b*) The buyer shall not, unless specially authorized by the Forest Officer in writing, remove from the limits of the area specified in article 1 of this indenture any part of the forest produce specified in the article before he has paid the first instalment provided for in article 2(*a*) of this indenture, nor during such time as any instalment payable by him may be in arrears or any fine or liability incurred by him under the provisions of this indenture may be unpaid or unsatisfied.

(*c*) If, at any time, the Forest Officer considers that the value of any forest produce exported by the buyer equals or exceeds the amount of the price paid by him up to that time, he may stop further export until the buyer has paid such further sum as in the opinion of the Forest Officer may be sufficient to cover the excess value of the forest produce exported or about to be exported.

Provided that the security money hereinafter mentioned shall not be taken into account in calculating the amount standing to the buyer's credit.

(*d*) If the buyer fails to pay any instalment provided for in article 2(*a*) or any part thereof on due date, he shall be liable to a fine which may extend to 1 per cent of the sum due for every twenty-four hours of delay, and to the stoppage of his export and to the confiscation of his forest produce and of the security money hereinafter mentioned, as well as of all or any other moneys already paid by him or on his behalf under this agreement, and to the cancellation of the sale made hereunder at the discretion of the Forest Officer and as he may direct.

Penalty for delay in work

3. If the buyer does not begin his work before the first day of December following the date of sale (or in the case of sales effected after the first day of November within a month from the date of sale), or having begun his work does not, in the opinion of the Forest Officer, prosecute it in an earnest and thorough manner or if the buyer voluntarily notifies to the Forest Officer his repudiation of this contract, the Forest Officer may declare this contract and the sale of such forest produce as has not till then been removed by the buyer cancelled and confiscate the security money and all or any other moneys already paid by or on behalf of the buyer under

this indenture, and if the said security and other moneys so forfeited are less than the above-mentioned sum of Rs————the remainder of the said sum of Rs————shall be recoverable from the said buyer provided that if the forest produce mentioned in clause 1 hereof or any part of it is resold within ————months after the date when this contract is cancelled credit shall be given to the buyer for the amount of money realized by such resale up to, but not exceeding, the amount recoverable from him under this clause; but if the amount realized by such resale exceeds the said sum of Rs————, the buyer shall not be entitled to such excess or any part thereof. If such produce or any part of it is resold after the expiry of the said———— months from the date when this contract is cancelled, the buyer shall not be entitled to credit for any part of the money realized by such resale but the Forest Officer may, if he thinks fit, give the buyer credit for such amount or any part thereof as he may consider proper.

Period for conversion and export

4. The buyer shall, unless otherwise specially authorized by the Forest Officer in writing, complete the conversion of the forest produce purchased by him and its removal beyond the limits of the specially fire-protected area to such depots as the Forest Officer may appoint by the————19 and its removal beyond the limits of the Forest Division and beyond such *chauki* as may be decided on and recorded in writing by the Forest Officer before sundown on the————19 .

If the buyer fails to comply with either of these conditions, the Forest Officer may confiscate the whole or any part of the forest produce not so removed and also the whole or any portion of the moneys paid therefor, and such forest produce and money shall be at the disposal of the seller and the buyer shall have no right thereto.

Registration of timber marks and of agents or servants

5. (*a*) The buyer shall register in the office of the Forest Officer his timber mark and also specimens of the signatures of any agents who may have been duly authorized by the Forest Officer to work for him, provided that the Forest Officer may refuse to accept any timber mark which is, in his opinion, unsuitable.

(*b*) The buyer shall furnish the Forest Officer, in writing, with the names, parentage, caste and residence of all agents or servants he proposes to employ within the Forest Division before they are so employed, and the Forest Officer shall be at liberty to forbid the employment of any person whom he may consider undesirable.

(*c*) The buyer shall furnish the Forest Officer in writing on such occasions and in such manner as the Forest Officer may direct with the names, parentage, caste and residence of all persons employed by him, within the Forest Division,

and the Forest Officer shall be at liberty to forbid the further employment of any person whom he may consider undesirable.

Measurement, marking and issue of passes for forest produce

6. (*a*) No timber shall be conveyed beyond the limits of the area mentioned in article 1 without being stamped at both ends with the buyer's timber mark and also with such other mark or marks as the Forest Officer may direct. The timber may also be counted and measured by the forest *muharrir*.

(*b*) If so directed by the Forest Officer, no forest produce shall be conveyed beyond the limits of the area mentioned in article 1 without a pass signed by the forest *muharrir* in such form as the Forest Officer may prescribe.

(*c*) No forest produce shall be exported from the area specified in article 1 except by such routes and via such *chauki* or *chaukis* as may be decided upon and recorded in writing by the Forest Officer and no wood other than fuel shall be removed beyond the said *chauki* or *chaukis* without being stamped with such Government mark as the Forest Officer may prescribe for use at each *chauki*. The forest produce may be counted and measured by the forest official in charge of each *chauki* and by any forest official at any time during transit.

(*d*) No forest produce shall be conveyed beyond the aforementioned *chauki* or *chaukis* or beyond the limits of the Forest Division without a *rawana* in such form as the Forest Officer may direct. Each such *rawana* shall accompany the consignment of forest produce to which it refers and shall be signed by the buyer or by one of his agents whose specimen signature has been registered under article 5(*a*).

Rules to be observed in the fellings

7. (*a*) The buyer shall cause no obstruction to roads or fire-lines by the felling, conversion or removal of the timber purchased by him.

(*b*) Unless authorized in writing by the Forest Officer, the buyer shall not remove the bole of a tree in more than one piece, or in any way convert his forest produce at any place which though outside the limits of the area mentioned in article 1 is within the limits of the reserved forest of the division.

(*c*) The Government hammer mark shall be left visible on the stumps of all trees felled by the buyer.

(*d*) After the fifteenth day of February fire shall not be used by the buyer or his agents or servants or employees within the limits of the specially fire-protected area of the division.

(*e*) The buyer shall not be wasteful in effecting the conversion of the forest produce purchased by him but shall utilize it to the full.

Liability for damage to Government property

8. (*a*) In the event of the buyer felling or converting a tree which he is not entitled to fell or convert under the terms of this indenture he shall be liable to pay a fine not exceeding Rs100 for each tree so felled or converted, and to the confiscation of his forest

produce and of the security money hereinafter mentioned as well as of all or any other moneys already paid by him or on his behalf under this contract and to the cancelling of this contract at the discretion of the Forest Officer and as he may direct:

Provided that if in the opinion of the Forest Officer the said felling or conversion was due to accident or to a reasonable excusable mistake on the part of the buyer or his agents or servants or employees the penalty shall be restricted to a fine which may extend to Rs100 for each tree thus felled or converted. The payment of any fine imposed under the terms of this article shall give the buyer no claim to the tree improperly felled or converted.

(*b*) In the event of the buyer negligently or deliberately felling a tree which he is entitled to fell under the terms of this indenture in such a direction as to cause damage to an unsold tree, such damage having been in the opinion of the Forest Officer avoidable by reasonably careful felling, he shall be liable to pay a fine not exceeding Rs50 at the discretion of the Forest Officer. The payment of such fine shall give the buyer no claim to the damaged tree.

(*c*) Should any sold tree be arrested in its fall by an unsold tree, in such manner that the former cannot be utilized without felling or injuring the latter, the buyer may be compelled to fell the unsold tree and to pay a fine, not exceeding Rs50 at the discretion of the Forest Officer. The payment of such fine shall give the buyer no claim to the unsold tree.

Vesting of the ownership of produce in the buyer

9. When the buyer shall have fulfilled all the conditions imposed upon him by this indenture in respect of the forest produce which he is entitled in terms of this indenture to convert and export, and when the said forest produce shall have been removed beyond the *chauki* decided on and recorded by the Forest Officer in terms of article 4, ownership of the said forest produce shall vest in the buyer.

Forest produce held to be at the buyer's risk

10. The forest produce sold to the buyer under this indenture will remain at the buyer's risk from the date hereof, and the seller will not be responsible for any loss or damage which may occur thereto from any cause whatever.

Encampments

11. The buyer, his agents or servants or employees shall not encamp within the specially fire-protected areas in the Forest Division except in such localities, and within such dates, as the Forest Officer may direct in writing.

12. The buyer may, with the permission in writing of the Forest Officer, take free of payment such forest produce as the Forest Officer may direct, from any area indicated by the said Forest Officer, for the purpose of providing shelter for his agents, servants or employees in his approved encampment, or for the

purpose of approved work undertaken in execution of this contract or in the process of extraction, conversion or export of the produce purchased hereunder. Such forest produce so taken shall always remain the property of the seller and may not be sold or removed from the boundaries of the forest without the permission in writing of the Forest Officer.

Assistance in case of fires in the forests

13. In the event of fire, from whatever cause, breaking out in the Forest Division, if he or they shall be called upon to do so by any forest official, the buyer and his agents, servants and employees present in any of the forests in the division shall at once, on becoming aware of it, proceed to the place and do their best to extinguish the fire.

General penalties

14. (*a*) The buyer holds himself responsible for the due observance, by his agents, servants and employees, of the terms and conditions of this indenture.

(*b*) In the event of a breach of any of the terms or conditions of this indenture by the buyer or by his agents or servants or employees the buyer in all those cases for which a special penalty has not been provided, shall be liable to pay a fine which may extend to fifty rupees for each such breach, at the discretion of the Forest Officer.

(*c*) Nothing in this indenture shall be held to exempt the buyer or his agents or servants or employees from liability to criminal proceedings for any breach of the forest laws or rules committed by him or them.

Suspected breach of agreement or forest offence

15. If a reasonable suspicion exists that a breach of any of the terms or conditions of this indenture or an offence against the Forest Act or against any rule made under that Act has been committed by the buyer or his agents or servants or employees, the Forest Officer may order the stoppage of the export of the buyer pending the investigation and decision of the case.

Verification of sale description

16. The seller does not guarantee either the number or the girth or the species or the soundness of the trees sold hereunder and will not give other trees in exchange for unsound ones.

Transfers

17. The buyer shall not be entitled to transfer his rights or liabilities under this indenture to anyone without the previous sanction in writing of the Forest Officer.

Recovery of arrears

18. Any money payable by the buyer and any fine imposed on him under this indenture remaining unpaid may be recovered by the seller in the manner prescribed by the law for the time being in force for recovery of arrears of land revenue.

19. In the event of a dispute arising concerning any of the terms or conditions of this indenture the same shall be referred to the Conservator of Forests,————Circle, whose decision shall be final.

Arbitration

20. The seller has received from the buyer the sum of Rs————— (Rupees————————————————) the receipt of which is hereby acknowledged, as security for the due fulfilment of all the covenants hereinbefore contained. The Forest Officer is empowered to deduct from such security money any sum which may be due from the buyer whether in respect of any instalment or other sum payable by him or of any fine or liability incurred by him under the provisions of this indenture. If not confiscated under the provisions of this indenture, the security money or such balance thereof as may be left after making the deduction aforementioned, will be returned to the buyer after the close of the operations, and after the Forest Officer shall have satisfied himself that all the terms of this indenture have been duly and faithfully carried out by the purchaser.

Security

21. It is agreed that the stamp duty, if any, payable for this indenture shall be paid by the seller.

Stamp

In witness whereof————————————on behalf of the Secretary of State for India in Council, and——————————— aforesaid, have hereto set their signatures.

Witness : ____________________ *Witness :* ____________________

Witness : ____________________ *Witness :* ____________________

V

FORM OF CONTRACT FOR SALE OF MINOR FOREST PRODUCE AND BAMBOOS ON LUMP SUM

THIS INDENTURE, made the——————day of—————— between the Secretary of State for India in Council (hereinafter called the 'seller') of the one part, AND——————————————————, son of —————— caste——————————, resident of—————————— in the district of——————————(hereinafter called the 'buyer') of the other part, witnesseth as follows:—

1. The seller in consideration of the payment by the buyer as hereinafter provided of the price of Rs——————(Rupees—————————————), hereby sells to the buyer, subject to the conditions hereinafter appearing and to the conditions published in the sale notice, a copy of which is hereto attached the following forest produce:—

(Description of forest produce and limits of area)

Forest produce within the limits of area above specified which are required for the use of the Government or for the holders of lawful rights, privileges, or concessions, or for use *bona fide* by other contractors in the work of conversion, collection or export of forest produce purchased by them, and grass utilized within the said area for feeding animals, are not included in the forest produce sold to the buyer hereunder.

2. (*a*) The buyer shall pay the aforesaid sum of Rs——————(Rupees ——————————) by the following instalments, namely:—

Rs——————on or before the ——————day of——————19 .
Rs——————on or before the——————day of——————19 .
Rs——————on or before the——————day of——————19 .
Rs——————on or before the——————day of——————19 .

All payments by the buyer shall be made into such Government treasury, or in such manner as the Divisional Forest Officer (hereinafter called the 'Forest Officer') shall direct.

(*b*) The buyer shall not, unless specially authorized by the Forest Officer in writing, remove from the limits of the area specified in article 1 of this indenture any part of the forest produce specified in that article before he has paid the first instalment provided for in article 2(*a*) of this indenture nor during such time as any instalment payable by him may be in arrears or any fine or liability incurred by him under the provisions of this indenture may be unpaid or unsatisfied.

(*c*) If at any time before payment in full of the price the Forest Officer considers that the value of any forest produce exported by the buyer equals or exceeds three-fourths of the amount of the price paid by him up to that time, he may stop further export until the buyer has paid such further sum as in the opinion of the Forest Officer may be sufficient to cover the excess of the forest produce exported or about to be exported:

Provided that the security money hereinafter mentioned shall not be taken into account in calculating the amount standing to the buyer's credit.

(*d*) If the buyer fails to pay any instalment provided for in article 2(*a*) or any part thereof on due date, he shall be liable to a fine, which may extend to 1 per cent of the sum due for every twenty-four hours of delay, and the stoppage of his export, and to the confiscation of the security money hereinafter mentioned, as well as of all or any other moneys already paid by him or on his behalf under this agreement, and to the cancellation of the sale made hereunder at the discretion of the Forest Officer and as he may direct.

Penalty for delay in work

3. If the buyer does not begin his work before the first day of December following the date of sale (or in the case of sales effected after the first day of November within a month from the date of sale), or having begun his work does not, in the opinion of the Forest Officer, prosecute it in an earnest and thorough manner or if the buyer voluntarily notifies to the Forest Officer his repudiation of this contract, the Forest Officer may declare this contract and the sale of such forest produce as has not till then been removed by the buyer cancelled and confiscate the security money and all or any other moneys already paid by or on behalf of the buyer under this indenture, and if the said security and other moneys so forfeited are less than the above-mentioned sum of Rs——————————, the remainder of the said sum of Rs——————————shall be recoverable from the buyer. Provided that if the forest produce mentioned in clause 1 hereof or any part of it is resold within——————————months after the date when this contract is cancelled, credit shall be given to the buyer for the amount of money realized by such resale up to, but not exceeding, the amount recoverable from him under this clause; but, if the amount realized by such resale exceeds the said sum of Rs——————————the buyer

shall not be entitled to such excess or any part thereof. If such produce or any part of it is resold after the expiry of the said——————————months from the date when this contract is cancelled, the buyer shall not be entitled to credit for any part of the money realized by such resale but the Forest Officer may, if he thinks fit, give the buyer credit for such amount or any part thereof as he may consider proper.

Period for conversion and export

4. The buyer shall, unless otherwise specially authorized by the Forest Officer in writing, complete the conversion of the forest produce specified in article 1 of this indenture and its removal beyond the limits of the specially fire-protected area to such depots as the Forest Officer may appoint by the——————————19 , and its removal beyond the limits of the Forest Division and beyond such *chauki* as may be decided on and recorded in writing by the Forest Officer before sundown on the——————————————19 , and in the absence of such special authorization the rights conveyed by article 1 of this indenture shall lapse in respect of forest produce not collected or not removed by the dates above assigned for completion of these respective operations.

Registration of agents or servants and employees

5. (*a*) The buyer shall furnish the Forest Officer, in writing, with the names, parentage, caste, residence and specimens of the signatures of all agents or servants he proposes to employ within the Forest Division before they are so employed and the Forest Officer shall be at liberty to forbid the employment of any person whom he may consider undesirable.

(*b*) The buyer shall furnish the Forest Officer in writing on such occasions and in such manner as the Forest Officer may direct with the names, parentage, caste and residence of all persons employed by him within the Forest Division and the Forest Officer shall be at liberty to forbid the further employment of any person whom he may consider undesirable.

Rules to be observed in export

6. (*a*) No forest produce shall be exported from the area specified in article 1 except by such routes and via such *chauki* or *chaukis* as may by decided upon and recorded in writing by the Forest Officer. The forest produce may be counted and measured by any forest official at any time during transit.

(*b*) Except with the special authorization of the Forest Officer, in writing, no forest produce shall be conveyed beyond the aforementioned *chauki* or *chaukis* or beyond the limits of the Forest Division, without a *rawana* in such form as the Forest Officer may direct. Each such *rawana* shall accompany the consignment of forest produce to which it refers, and shall be signed by the buyer or by one of his agents registered under article 5(*a*). In the event of the buyer or

his agents being authorized to issue *rawanas*, all *rawana* books, used and unused, shall be submitted intact to the Forest Officer at the close of the operation.

Rules to be observed in collection

7. (*a*) The buyer shall cause no obstruction to roads or fire-lines in the collection or removal of the forest produce specified in article 1 of this indenture.

(*b*) After the fifteenth day of February or such other date as the Forest Officer may notify in terms of section 26(1)(*c*) of the Indian Forest Act (XVI of 1927), fire shall not be kindled, kept or carried by the buyer or his agents or servants or employees within the limits of the specially fire-protected area of the division.

(*c*) No bamboo shoots of the previous monsoon's growth shall be cut by the buyer.

(*d*) The forest produce specified in article 1 of the indenture shall not be stacked within the limits or within 500 feet of the boundary of the Forest Division except at such places and in accordance with such rules as the Forest Officer may from time to time prescribe in writing.

Vesting of the ownership of the forest produce in the buyer

8. When the buyer shall have fulfilled all the conditions imposed on him by this indenture in respect of the forest produce which he is entitled in terms of this indenture to collect and export, and when the said forest produce shall have been removed beyond the limits of the Forest Division and beyond such *chauki* as may have been decided on and recorded by the Forest Officer in terms of article 4, ownership of the said forest produce shall vest in the buyer.

Forest produce held to be at the buyer's risk

9. The forest produce specified in article 1 of this indenture will remain at the buyer's risk from the date hereof, and the seller will not be responsible for any loss or damage which may occur thereto from departmental burning operations or from any other cause whatsoever.

Encampments

10. The buyer, or his agents or servants or employees, shall not encamp within the specially fire-protected areas in the Forest Division, except in such localities, and within such dates, as the Forest Officer may direct in writing.

11. The buyer may, with the permission in writing of the Forest Officer, take free of payment such forest produce as the Forest Officer may direct, from any area indicated by the said Forest Officer, for the purpose of providing shelter for his agents, servants or employees in his approved encampment, or for the purpose of approved work undertaken in execution of this indenture or in the process of extraction, conversion or export of the produce purchased hereunder. Such forest produce so taken shall always remain the property of the seller and may not be sold or removed from the boundaries of the forest without the permission in writing of the Forest Officer.

Assistance in case of fires in the forest

12. In the event of fire, from whatever cause, breaking out in the Forest Division the buyer and his agents, servants and employees present in any of the forests in the division shall at once, on becoming aware of it, proceed to the place and do their best to extinguish the fire.

General penalties

13. (*a*) The buyer holds himself responsible for the due observance by his agents, servants and employees of the terms and conditions of this indenture.

(*b*) In the event of a breach of any of the terms or conditions of this indenture by the buyer or by his agents, servants or employees the buyer, in all those cases for which a special penalty has not been provided, shall be liable to pay a fine which may extend to fifty rupees for each such breach, at the discretion of the Forest Officer.

(*c*) Nothing in this indenture shall be held to exempt the buyer or his agents, servants or employees from liability to criminal proceedings for any breach of the forest laws, or rules, committed by him or them.

Suspected breach of agreement or forest offence

14. If a reasonable suspicion exists that a breach of any of the terms or conditions of this indenture or an offence against the Forest Act or against any rule made under that Act has been committed by the buyer, or his agents, servants or employees, the Forest Officer may order the stoppage of the export of the buyer pending the investigation and decision of the case.

Verification of sale description

15. The seller does not guarantee the number, quantity or quality of the forest produce specified in article 1 of this indenture.

Transfers

16. The buyer shall not be entitled to transfer his rights or liabilities under this indenture to anyone without the previous sanction in writing of the Forest Officer.

Recovery of arrears

17. Any money payable by the buyer and any fine imposed upon him under the indenture remaining unpaid may be recovered by the seller in the manner prescribed by the law for the time being in force for recovery of arrears of land revenue.

Arbitration

18. In the event of any dispute arising concerning any of the terms or conditions of this indenture the same shall be referred to the Conservator of Forests,——————————Circle, whose decision shall be final.

Security

19. The seller has received from the buyer the sum of Rs—————————— (Rupees——————————), the receipt of which is hereby acknowledged as security for the due fulfilment of all the covenants hereinbefore contained. The Forest Officer is empowered to deduct

from such security money any sum which may be due, from the buyer, whether in respect of any instalment or other sum payable by him or of any fine or liability incurred by him under the provisions of this indenture. If not confiscated under the provisions of this indenture, the security money or such balance thereof as may be left after making the deduction aforementioned, will be returned to the buyer after the close of the operations, and after the Forest Officer shall have satisfied himself that all the terms of this indenture have been duly and faithfully carried out by the buyer.

Stamp 20. It is agreed that the stamp duty, if any, payable for this indenture shall be paid by the seller.

In witness whereof———————————————on behalf of the Secretary of State for India in Council, and——————————————aforesaid, have hereto set their signatures.

Witness: *Witness:*

————————— —————————

Witness: *Witness:*

————————— —————————

DEHRA DUN FOREST DIVISION

LIST

OF

Timber and other Forest Produce

FOR THE YEAR 1935-36

TO BE SOLD

BY PUBLIC AUCTION ON 19th AND 20th AUGUST, 1935

AT THE

DIVISIONAL FOREST OFFICE

IN

DEHRA DUN, U.P.

NOTE—Bring this copy of the Sale Notice and Sale Rules with you to the Auctions

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देहरादून फ़ौरेस्ट डिवीज़न

फ़ेहरिस्त लकड़ी व दीगर पैदावार जङ्गल

बाबत सन् १९३५–३६ जो बज़रिये नीलाम मुक़ाम डिवीज़नल फ़ौरेस्ट आफ़िस—देहरादून

तारीख़ १९, २० अगस्त १९३५ को फ़रोख़्त होगी

नोट—ठेकेदारान फ़ेहरिस्त हाज़ा और क़वायद बिक्री को नीलाम के वक़्त अपने साथ लेते आवें

دہرہ دون فاریسٹ ڈویزن

فہرست لکڑی و دیگر پیداوار جنگل

بابت سنہ ۳۶-۱۹۳۵ع - جو بذریعہ نیلام

مقام ڈویزنل فاریسٹ آفس - دہرہ دون

تاریخ ۱۹ و ۲۰ اگست سنہ ۱۹۳۵ع کو فروخت ہوگی

نوٹ — ٹھیکیداران فہرست ہذا اور قواعد فروخت کو نیلام کے وقت اپنے ساتھ لیتے آوین

GREEN AND DRY TREES TO

हरे व सूखे पेड़ जो गोल ठेके पर बेचे जावेंगे।

Range—Timli, Working Circle—Sal Conversion, P.B.—Inter,

रेंज—तिमली, वर्किंग सरकिल—साल कनवरशन, पी० बी०—इन्टर,

پی بی انٹر - ورکنگ سرکل سال کنورشن - رینج تملی

Nearest Railway Station—Dehra Dun. नजदीकी रेलवे स्टेशन—

Nearest Road—Saharanpur-Chakrata. नजदीक की सड़क—

Name of purchaser— Price realized—Rs.

Lot No. लाट नं० لاٹ نمبر	Species किस्म पेड़ قسم پیڑ			Diameter in inches कुतर						
					12"–16" १२"-१६" ١٦"-١٢"			16"–20" १६"-२०" ٢٠"-١٦"		
			0"–8" ०"-८" ٨"-٠"	8"–12" ८"-१२" ١٢"-٨"	Sound ठोस ٹھوس	Hollow खोकल کھوکل Fit क़ाबिल قابل	Hollow खोकल کھوکل Unfit नाक़ा० ناقابل	Sound ठोस ٹھوس	Hollow खोकल کھوکل Fit क़ाबिल قابل	Hollow खोकल کھوکل Unfit नाक़ा० ناقابل
1	Sal green	साल हरा	سال ہرا	98	122	10	10	41	1	3	50
१	Sal dry	साल सूखा	سال سوکھا	27	22	3	7	7	...	2	1
١	Sain	सैन	سین	4	4	...	1	...	...	2	...
	Sandan	सांदन |ساندن	25	1	...	1	...	...	...	...
	Haldu	हल्दू	ہلدو	...	...	...	...	...	...	...	...
	Kokat	कोकाट	کوکاٹ	35	17	...	3	2	...	...	...

Period of work and export—From

मियाद काम व निकासी—१ अक्तूबर सन् १९३५ ई० से ३१ मार्च सन् १९३६ ई० तक।

BE SOLD BY LUMP SUM

ہرے اور سوکھے پیڑ جو گول ٹھیکہ پر بیچے جاوینگے

Block—Dharmawala, Compartment—*3b*, Area—176 acres

ब्लोक—धर्मावाला, कम्पार्टमेन्ट—३बी, रक़बा—१७६ एकड़

رقبہ ۱۷۶ ایکڑ - کمپارٹمنٹ ۳بی - بلوک دہرماوالا

देहरादून — نزدیکی ریلوے اسٹیشن — دہرہ دون

सहारनपुर–चकराता — نزدیکی سڑک — سہارنپور - چکراتہ

Security money—Rs.

इञ्चों में قطر انچون مین						
20″–24″ २०″-२४″ ۲۰″-۲۴″			24″ and over २४″ से ऊपर ۲۴″ سے اوپر			Total मीज़ान میزان
Sound ठोस ٹھوس	Hollow खोकल کھوکل — Fit क़ाबिल قابل	Hollow खोकल کھوکل — Unfit नाक़ा० ناقابل	Sound ठोस ٹھوس	Hollow खोकल کھوکل — Fit क़ाबिल قابل	Hollow खोकल کھوکل — Unfit नाक़ा० ناقابل	
...	5	27	...	15	50	432
...	...	1	...	...	3	73
...	...	...	...	...	...	11
...	...	...	...	...	...	27
...	...	...	...	...	1	1
...	...	2	...	...	...	59

Remarks कैफ़ियत کیفیت

Felled and fallen firewood, including lopped material from marked trees, is not included in the sale of this lot. Only sawn and round timber from the marked trees may be exported.

कुल गिरा और गिराया हुआ सोख़्ता और छपे हुए पेड़ों की शाख तराशी की लकड़ी जो इस लाट में है बिक्री में शामिल नहीं है महज़ छपे हुये पेड़ों से चिरांद शुदा और गोल इमारती लकड़ी निकासी की जा सकती है ।

کُل گرا اور گرایا ہوا سوختہ اور چھپے ہوئے پیڑون کی شاختراشی کی لکڑی جو اس لاٹ مین ہے بکری مین شامل نہین ہے - محض چھپے ہوئے پیڑون سے چراند شدہ اور گول عمارتی لکڑی نکاسی کی جاسکتی ہے ۔

ctober 1, 1935 to March 31, 1936.

میعاد کام و نکاسی—یکم اکتوبر سنہ ۱۹۳۵ع سے ۳۱ مارچ سنہ ۱۹۳۶ع تا

GREEN AND DRY TREES TO

हरे व सूखे पेड़ जो गोल ठेके पर बेचे जावेंगे

Range—Malhan, Working Circle—Sal Conversion, P.B.—I

रेंज—मल्हान, वर्किंग सरकिल—साल कनवरशन, पी० बी०—१

والا - پی بی ۱ - ورکنگ سرکل سال کنورشن - رینج ملہان

Nearest Railway Station—Dehra Dun. नजदीकी रेलवे स्टेशन—

Nearest Road—Chakrata-Dehra Dun. नजदीक की सड़क—

Name of purchaser— Price realized—Rs.

Lot No. लाट नं० لاٹ نمبر	Species किस्म पेड़ قسم پیڑ	Diameter in inches							कुत
				12″–16″ १२″-१६″ ١٢-″١٦″			16″–20″ १६″-२०″ ١٦-″٢٠″		
					Hollow खोकल کھوکل			Hollow खोकल کھوکل	
		0″–8″ ०″-८″ ٠-″٨″	8″–12″ ८″-१२″ ٨-″١٢″	Sound ठोस ٹھوس	Fit क़ाबिल قابل	Unfit नाक़ा० ناقابل	Sound ठोस ٹھوس	Fit क़ाबिल قابل	Unfit नाक़ा० ناقابل
2	Sal green साल हरा سال ہرا	17	25	142	361	12	33	312	15
२	Sal dry साल सूखा سال سوکھا	1	2	...	...	...	...	...	1
٢	Sain green सैन हर سین ہرا	...	1	5	7	1	17	2	..
	Sain dry सैन सूखा سین سوکھا	2	...	...	1	...	...	...	...
	Sandan green सांदन हरा ساندن ہرا	1	1	...	...	...	...	...	...
	Sandan dry सांदन सूखा ساندن سوکھا	1	1	...	...	...	...	...	...
	Bahera बहेरा بہیڑا	...	...	...	...	...	...	...	1
	Kokat green कोकाट हरा کوکاٹ ہرا	19	2	...	4	3	1	3	2
	Kokat dry कोकाट सूखा کوکاٹ سوکھا	16	3	...	2	3	...	...	...

Period of work and export—From

मियाद काम व निकासी—१ अक्तूबर सन् १९३५ ई० से ३१ मार्च सन् १९३६ ई० तक

BE SOLD BY LUMP SUM

ہرے اور سوکھے پیڑ جو گول ٹھیکہ پر بیچے جاوینگے

Block—Kaluwala, Compartment—7*b*, Plot 1, Area—53 acres

ब्लोक—कालूवाला, कम्पार्टमेंट —७बी प्लाट १, रक़बा—५३ एकड़

رقبہ ۵۳ ایکڑ - کمپارٹمنٹ ۷ بی پلاٹ ۱ - بلوکم

देहरादून

نزدیکی ریلوے اسٹیشن—دہرہ دون

चकराता—देहरादून

نزدیکی سڑک—چکراتہ - دہرہ دون

Security money—Rs.

इञ्चों में قطر انچوں مین						
20"–24" २०"-२४" ۲۰"-۲۴"			24" and over २४" से ऊपर ۲۴" سے اوپر			Total मीज़ान میزان
Sound ठोस ٹھوس	Hollow खोकल کھوکل Fit क़ाबिल قابل	Hollow खोकल کھوکل Unfit नाक़ा० ناقابل	Sound ठोस ٹھوس	Hollow खोकल کھوکل Fit क़ाबिल قابل	Hollow खोकल کھوکل Unfit नाक़ा० ناقابل	
7	165	4	1	77	2	1,173
...	1	...	...	...	...	5
5	1	...	...	...	...	39
...	...	...	...	...	...	3
...	...	...	...	...	...	2
...	...	...	...	...	...	2
...	...	...	...	...	...	1
...	2	...	...	...	...	36
...	...	...	...	...	...	24

Remarks कैफ़ियत کیفیت

Felled and fallen firewood, including lopped material from marked trees, is not included in the sale of this lot. Only sawn and round timber from the marked trees may be exported.

कुल गिरा और गिराया हुआ सोख़्ता और छपे हुए पेड़ों की शाख तराशी की लकड़ी जो इस लाट में है बिक्री में शामिल नहीं है महज़ छपे हुए पेड़ों से चिरांद शुदा और गोल इमारती लकड़ी निकासी की जा सकती है ।

کُل گرا اور گرایا ہوا سوختہ اور چھپے ہوئے پیڑون کی شاختراشی کی لکڑی جو اس لاٹ مین ہے بکری مین شامل نہین ہے - محض چھپے ہوئے پیڑون سے چراند شدہ اور گول عمارتی لکڑی نکاسی کی جاسکتی ہے ۰

October 1, 1935 to March 31, 1936.

میعاد کام و نکاسی—یکم اکتوبر سنہ ۱۹۳۵ع سے ۳۱ مارچ سنہ ۱۹۳۶ع تک

FALLEN FIREWOOD TO

गिरा हुआ सोख्ता जो गोल ठेके पर बेचा जावेगा

Lot No. लाट नं० لاٹ نمبر	Range रैंज رینج	Block ब्लोक بلاک	Compartment कम्पार्टमेन्ट کمپارٹمنٹ
64 ६४ ٦٤	Barkot बड़कोट بڑکوٹ	Golatappar गोलातप्पड़ گولاپڑ	7A
65 ६५ ٦٥	Ditto	Ghamandpur گھمنڈپور घमंडपुर	6 part (felled in 1934–35) १९३४-३५ के कटान का टुकड़ा ۱۹۳۴-۳۵ کے کٹان کا ٹکڑا
66 ६६ ٦٦	Ditto	Ditto ...	7
67 ६७ ٦٧	Ditto	Bibiwala बीबीवाला بی بی والہ	7A and 9A
68 ६८ ٦٨	Thano थानों تھانو	Ramnagar रामनगर رام نگر	20 part and 27
69 ६९ ٦٩	Ditto	Ditto ...	7 part and 73, 74 and 5B
70 ७० ٧٠	Ditto	Lambirao लम्बीराव لمبی راو	35, 61, 62 and 59
71 ७१ ٧١	Ditto	Ditto ...	40

BE SOLD ON LUMP SUM

گرا ہوا سوختہ جو گول ٹھیکہ پر بیچا جاویگا

Area in acres रक़बा एकड़ों में رقبه ایکڑون مین	Price realized	Security money	Period for work and export मियाद काम और निकासी میعاد کام اور نکاسی	Name of purchaser	Remarks कैफ़ियत کیفیت
212			From 1st October, 1935 to 31st March, 1936 एक अक्तूबर सन् १९३५ ई० से ३१ मार्च सन् १९३६ ई० तक یکم اکتوبر سنہ ۱۹۳۵ع سے ۳۱ مارچ سنہ ۱۹۳۶ع تک		(1) Firewood includes all fallen material not capable of producing *bullis*, *tors*, or fashioned timber of any sort. (१) सोख़्ता में वह गिरी पड़ी लकड़ी शामिल नहीं है जिससे बल्ली टोर या किसी किस्म का चिरान का अदद निकल सके। (۱) سوختہ مین وہ گری پڑی لکڑی شامل نہین ہے جس سے بلی ٹور یا کسی قسم کا چران کا عدد نکل سکے ۔ (2) Export will be permitted along old cart tracks only. (२) निकासी की इजाज़त सिर्फ़ पुरानी गाड़ी की लीकों से होगी। (۲) نکاسی کی اجازت صرف پرانی گاڑی کی لیکون سے ہوگی ۔
500					
268					
307					
91					
230					
186					
68					

LIMESTONE BOULDERS AND

चूने का पत्थर और दरिया बुर्दी लकड़ी गोल ठेके पर बेचने के लिये

Lot No. लाट नं० لاٹ نمبر	Range रैंज رینج	Locality and boundary जगह और हद جگہ اور حد	Price realized	Security money	Period for work and export मियाद काम और निकासी میعاد کام اور نکاسی
72 ७२ ۷۲	Malhan मल्हान ملہان	All *raus* in Bainkhala block, including Tons Nadi. तमाम रौ बायांखाला ब्लौक मय टौंस नदी تمام رو بائینکھالہ بلاک مع ٹونس ندی			June 30, 1936. ३० जून १९३६ ई० ۳۰ جون سنہ ۱۹۳۶ ع
73 ७३ ۷۳	Lachiwala लच्छीवाला لچھیوالا	Suswa River within the boundary of Lachiwala Range. सुसवा नदी लच्छीवाला रैंज की हद में سسوا ندی لچھیوالا رینج کی حد مین			
74 ७४ ۷۴	Barkot बड़कोट بڑکوٹ	Fatehpore reserve. फ़तहपुर जंगल فتح پور جنگل			
75 ७५ ۷۵	Thano थानो تھانو	Bidhalna *rau*, Jakhan *rau* and Sansarukhala *rau*. बिधालनारौ, जाखनरौ और संसारूखालारौ بدھالنا رو - جاکھن رو - اور سنساروکھالہ رو			
76 ७६ ۷۶	Thano थानो تھانو	The Song river, Lambi *rau*, Rehar *rau*, Chittur *rau*, Palasi *rau* and Sarwargarh *rau*. सौंग नदी, लमबीरौ, रीहड़रौ, चितौड़रौ, पलासीरौ और सरवरगढ़रौ سونگ ندی - لمبی رو - ریہڑ رو - چتوڑ رو - پلاسی رو اور سرورگڑھہ رو			
77 ७७ ۷۷	Barkot बड़कोट بڑکوٹ	All *raus*, except those in Tapoban, Birbhadar, Ghamandpur, Golatappar, Sainkot and Bibiwala blocks. तमाम रौ बड़कोट रैंज सिवाय तपोबन और बीरभद्र, घमन्डपुर और गोलातप्पड़ और सेनकोट और बीबीवाला ब्लोक تمام رو بڑکوٹ رینج سواے تپوبن اور ویربھدر - گھمنڈپور گولاتپڑ سینکوٹ اور بی بی والا بلاک			
78 ७८ ۷۸	Motichoor मोतीचूर موتی چور	All *raus* in Banbaha and Chandi blocks; but *khair* trees and parts of *khair* trees are excluded from this lot. तमाम रौ बनबहा और चांडी ब्लोकों में, मगर खैर के पेड़ और खैर के पेड़ों के हिस्से इस लाट में शामिल नहीं हैं تمام رو بنبہا اور چانڈی بلاکون مین - مگر کھیر کے پیڑ اور کھیر کے پیڑون کے حصہ اس لاٹ مین شامل نہین ہین			
79 ७९ ۷۹	Ditto ऐ० ایضاً	All *raus* in Suswa block. तमाम रौ सुसवा ब्लोक में تمام رو سسوا بلاک مین			

DRIFTWOOD LUMP SUM SALE

چونے کا پتھر اور دریا برد لکڑی گول ٹھیکہ پر بیچنے کے لئے

Name of purchaser	Remarks कैफ़ियत کیفیت

(1) Drift sal trees attacked by Hoplocerambyx beetle are not included in the sale of lots Nos. 72 and 76.

(१) लाट नं० ७२ और ७६ में जिस किसी दरया बुरदी माल में होप्लोसिरेम्बिक्स कीड़ा लगा हो वह बिक्री में शामिल नहीं है।

(۱) لاٹ نمبری ۷۲ و ۷۶ مین جس کسی دریا بردی سال مین ہوپلوسیرمبیکس کیڑا لگا ہو وہ بکری مین شامل نہین ہے ۔

(2) The purchasers will only be permitted to burn lime in places pointed out by the Range Officer.

(२) खरीदारान चूना सिर्फ़ उन जगहों पर जलावेंगे जहां पर रेंज आफ़िसर इजाजत दें।

(۲) خریداران چونہ صرف اُن جگہون پر جلاوینگے جہان پر رینج افیسر اجازت دین ۔

(3) The wood sold in these lots includes only such trees and parts of trees as are drift in the river beds and are not attached by any parts of the roots to the place where the trees were standing.

(३) इन लाटों में जो लकड़ी बेची गई है उसमें सिर्फ़ ऐसे पेड़ व पेड़ों का हिस्सा शामिल होगा जो कि नदियों के रौखड़ में बह कर आये हों और जड़ों के किसी हिस्से से उन जगहों पर न लगे हों जहा पर कि वह खड़े थे।

(۳) ان لاٹون مین جو لکڑی بیچی گئی ہے اُس مین صرف ایسے پیڑ و پیڑون کا حصہ شامل ہوگا جوکہ ندیون کے روکھڑ مین بہکر آئے ہین اور جڑون کے کسی حصے سے ان جگہون پر نہ لگے ہون جہان پر کہ وے کھڑے تھے ۔

(4) No wood fallen or otherwise which is lying inside the tree forest is included in these lots.

(४) कोई लकड़ी गिरी पड़ी या दीगर क़िस्म जो कि जंगल के अन्दर पड़ी हो इन लाटों में बिलकुल शामिल नहीं है।

(۴) کوئی لکڑی گری پڑی یا دیگر قسم جوکہ جنگل کے اندر پڑی ہو ان لاٹون مین بالکل شامل نہین ہے ۔

(5) No floating of timber or firewood will be allowed in the Song and Suswa rivers.

(५) सौंग और सुस्वा दरयाओं में कोई इमारती या दीगर लकड़ी बहा कर ले जाने की इजाजत नहीं है।

(۵) سونگ اور سسوا دریاؤن مین کوئی عمارتی یا دیگر لکڑی بہاکر لے جانے کی اجازت نہین ہے ۔

ROHNI FRUIT (KAMILA) LUMP SUM SALE

रोहनी का फल (कमीला) गोल ठेके पर बेचने के लिये

روھنی کا پھل (کمیلا) گول ٹھیکہ پر بیچنے کے لئے

Lot No. लाट नं० لاٹ نمبر	Range रेंज رینج	Locality and boundary जगह और हद جگہہ اور حد	Price realized	Security money	Period for work and export میعاد کام اور نکاسی मियाद काम और निकासी	Name of purchaser	Remarks कैफ़ियत کیفیت
80 ८० ٨٠	Timli टिमली ٹملی	Whole range कुल रेंज کل رینج			۳۰ اپریل سنہ ۱۹۳٦ع ३० अप्रैल १९३६ ई० April 30, 1936.		No branch more than one inch in diameter should be cut. कोई शाख़ एक इन्च क़ुतुर से ज़्यादा नहीं काटी जावेगी । کوئی شاخ ایک انچ سے زیادہ قطر کی نہین کاٹی جاویگی ۔ *Rohni* trees in the compounds of Forest buildings are not included in the sale. जंगलात की इमारतों के अहातों में जो रोहनी के पेड़ हैं वह बिक्री में शामिल नहीं हैं । جنگلات کی عمارتون کے احاطون مین جو روھنی کے پیڑ ھین وہ فروخت مین شامل نہین ھین ۔
81 ८१ ٨١	Malhan मलहान ملہان	Ditto ऐ० ایضاً					
82 ८२ ٨٢	Lachiwala लच्छीवाला لچھی والا	Ditto ऐ० ایضاً					
83 ८३ ٨٣	Thano थानो تھانو	Ditto ऐ० ایضاً					
84 ८४ ٨٤	Barkot बड़कोट بڑکوٹ	Ditto ऐ० ایضاً					
85 ८५ ٨٥	Motichoor मोतीचूर موتی چور	Ditto ऐ० ایضاً					

BAIB (OR BHABAR) GRASS LUMP SUM SALE

बेब या भाबर घास गोल ठेके पर बेचने के लिये

بیب یا بھابر گھاس گول ٹھیکہ پر بیچنے کے لئے

Lot No. लाट नं० لاٹ نمبر	Range रेन्ज رینج	Locality and boundary जगह और हद جگہہ اور حد	Price realized	Security money	Period for work and export मियाद काम और निकासी میعاد کام اور نکاسی	Name of purchaser	Remarks कैफ़ियत کیفیت
105 १०५ ۱۰۵	Motichoor मोतीचूर موتی چور	Bahera, Koelpura (excluding c. 4b, c. 5b and c. 9) and Jamankhata blocks. बहेड़ा, कोयलपुरा (अलावा कम्पार्टमेन्ट ४ बी, ५ बी और ९ के) और जामनखाता ब्लौक بہیڑا - کوئلپورا (علاوہ کمپارٹمنٹ ۴بی - ۵بی اور ۹ کے) اور جامن کھاتہ بلاک ۰			April 15, 1936. १५ अप्रैल १९३६ ई० ۱۵ اپریل سنہ ۱۹۳۶ع		(1) All *tappars* will be burnt as early in the season as possible, probably in December, 1935. Compartments and sub-compartments in P.B. IX will be burnt departmentally on dates to be fixed by the Range Officer concerned. (१) जाड़ों में कुल तप्पड़ों का फुकांद इतनी जल्दी जितना कि हो सकेगा किया जायगा। ग़ालिबन दिसम्बर १९३५ तक पी, बी, ९ के कम्पार्टमेन्ट और सब कम्पार्टमेन्टों में फुकांद की तारीख़ रेंज अफ़सर मुताल्लिक़ा मुक़र्रर करेंगे। (۱) جاڑون مین کل تپڑون کا پھوکاند اتنی جلدی جتنا کہ ہوسکیگا کیا جاویگا - غالباً دسمبر سنہ ۱۹۳۵ع تک پی - بی - ۹ کے کمپارٹمنٹ اور سب کمپارٹمنٹ مین پھوکاند کی تاریخ رینج افسر متعلقہ مقرر کرینگے ۰
106 १०६ ۱۰۶	Ditto. ऐज़न ایضاً	Motichoor (excluding c. 1b, c. 5a and c. 7b), Danda and Johra blocks. मोतीचूर (अलावा कम्पार्टमेन्ट १ बी, ५ ए और ७ बी) और डांडा और जोहड़ा ब्लौक موتی چور (علاوہ کمپارٹمنٹ ۱بی - ۵اے اور ۷بی) اور ڈانڈا اور جوھڑا بلاک ۰					

GRASS AND OTHER MINOR FOREST

घास और दूसरी पैदावार जंगल गोल ठेके पर बेचने के लिये

Lot No. लाट नं० لاٹ نمبر	Range रैंज رینج	Locality and boundary जगह और हद جگہ اور حد	Price realized	Security money	Period for work and export मियाद काम और निकासी میعاد کام اور نکاسی
86 ८६ ۸۶	Timli टिमली تملی	Chandpore forests excluding c. 2 and 3. चांदपूर जंगल अलावा कम्पार्टमेन्ट २ और ३ چاندپور جنگل علاوہ کپارٹمنٹ ۲ و ۳			For lots 96 to 100 up to April 15, 1936, for lots 101 to 104 up to January 15, 1936. लाट नम्बर ९६ से १०० तक तारीख १५ अपरैल सन् १९३६ तक लाट नम्बर १०१ से १०४ तक ता० १५ जनवरी सन् १९३६ ई० لاٹ نمبر ۹۶ سے ۱۰۰ تک تاریخ ۱۵ اپریل ۱۹۳۶ء لاٹ نمبر ۱۰۱ سے ۱۰۴ تک تاریخ ۱۵ جنوری سنہ ۱۹۳۶ء تک
87 ८७ ۸۷	Ditto ऐ० ایضاً	Ambari forests (Langha and Dumet blocks). अमबारी जंगल (लांघा व डुमेट ब्लोक) امباڑی جنگل (لانگھا اور ڈمیٹ بلاک)			
88 ८८ ۸۸	Ditto ऐ० ایضاً	Dhāula and Kulhal blocks. धौला व कुलहाल ब्लोक دھولا و کلہال بلاک			
89 ८९ ۸۹	Ditto ऐ० ایضاً	Aduwala and Dararit blocks. आदूवाला व दरारीट ब्लोक آدووالا و دراریٹ بلاک			
90 ९० ۹۰	Ditto ऐ० ایضاً	Dharmawala (excluding c. 12a), Majri (excluding c. 5 and c. 6) and Sahensra (excluding c. 4 and c. 6) blocks. धरमावाला (अलावा कम्पार्टमेन्ट १२ए), माजरी (अलावा कम्पार्ट ५ और ६) और सहंसरा (अलावा कम्पार्ट ४ और ६) ब्लोक دھرماوالا (علاوہ کپارٹ ۱۲اے) - ماجری (علاوہ کپارٹ ۵ اور ۶) و سہنسرا (علاوہ کپارٹ ۴ اور ۶) بلاک			
91 ९१ ۹۱	Ditto ऐ० ایضاً	Dharmawala 12a. धरमावाला १२ए دھرماوالا ۱۲اے			
92 ९२ ۹۲	Ditto ऐ० ایضاً	Sahensra 4 and 6. सेहंसरा ४, ६ سہنسرا ۴ و ۶			

PRODUCE LUMP SUM SALE

گھاس اور دوسری پیداوار جنگل گول ٹھیکہ پر بیچنے کے لئے

Name of purchaser	Remarks कैफ़ियत کیفیت
	(1) Other minor produce includes fruits except mangoes and *rohni* (*kamila*) leaves only of *maljhan*, *maljhan* fibre, edible roots and stems of *kapasi* (*Helictere isora*) except in areas where regeneration fellings are going on. (१) दूसरी पैदावार जंगल में कुल फल सिवाय आम और रोहनी (कमीला के) मालझ की पत्तियां और गुदाला, खाने लायक जड़ें और कपासी के तने शामिल हैं सिवाय उन रक़ब के जहां रिजेनरेशन फ़ेलिंग हो रहा है। (۱) دوسری پیداوار جنگل مین کل پھل سواے آم اور روہنی (کیلا) کے مالجھن کے پتے اور گدالا - ھانے لایق جڑین اور کپاسی کے تنے شامل هین سواے اُن رقبون کے جہان ریجنریشن فیلنگ هو رہا ہے ۔ (2) The following are not included: gum, hides, horns, bones, honey, wax bark and leaves (except of *maljhan*). (२) तफ़सील ज़ैल चीज़ें इसमें शामिल नहीं हैं, गोंद, चमड़ा, सींग, हड्डी, शहद, मोम छाल और पत्तियां (सिवाय मालझन के) (۲) تفصیل ذیل چیزین اس مین شامل نہین هین - گوند - چمڑا - سینگ - هڈی - شہد - موم - چھال اور پتیان سواے مالجھن کے) ۔ (3) All *tappars* will be burnt as early in the season as possible. Compartments and sub-compartments in P.B. IX will be burnt departmentally on dat to be fixed by the Range Officer concerned. (३) जाड़ों में कुल तप्पड़ों का फुकांद इतनी जल्दी जितनी कि हो सकेगा किया जावेगा- पी० बी० ९ के कम्पार्टमेन्ट और सब कम्पार्टमेन्टों में फुकांद की तारीख़ रेंज अफ़सर मुताल्लि मुक़र्रर करेंगे। (۳) جاڑون مین کل تپڑون کا پھکاند اتنی جلدی جتنی کہ هوسکیگا کیا جاویگا پی - بی - ۹ کے کمپارٹمنٹ سب کمپارٹمنٹ مین پھوکاند کی تاریخ رینج افسر متعلقہ مقرر کرینگے ۔

चारा घास गोल ठेके पर बेचने के लिये

چارہ گھاس گول ٹھیکہ پر بیچنے کے لئے

लाट नं० لاٹ نمبر	Range रेन्ज رینج	Locality and boundary जगह और हद جگہ اور حد	Price realized	Security money	Period for work and export मियाद काम और निकासी میعاد کام اور نکاسی	Name of purchaser	Remarks कैफ़ियत کیفیت
07 ०७ ١٠٧	Malhan ملہان मल्हान	Kalianpur (excluding c. 3b, c. 6, c. 7 and c. 8), Kaluwala (excluding c. 6) and Malhan (excluding c. 1, c. 2 and c. 3) blocks. कल्यानपुर (अलावा कम्पार्ट ३ब, ६, ७ और ८), काल्वाला (अलावा कम्पार्ट ६) और मल्हान (अलावा कम्पार्ट १, २ और ३) ब्लौक کلیانپور (علاوہ کمپارٹ ۳بی ٦ - ۷ اور ۸) کالووالا (علاوہ کمپارٹ ٦) اور ملہان (علاوہ کمپارٹ ۱ و ۲ و ۳) بلاک			۱۵ اپریل سنہ ۱۹۳۶ع १५ अप्रैल १९३६ ई० April 15, 1936.		(1) The *taungya* cultivators of the division are allowed to cut grass free of charge for their *bona fide* domestic use and to graze their cattle free of charge. (१) डिवीजन हाजा के टौंगिया के काश्तकारान को अपने जरूरी निजी इस्तेमाल के लिये मुफ़्त घास काटने की और अपने मवेशी मुफ़्त चराने की इजाजत है। (۱) ڈویزن ھذا کے ٹانگیا کے کاشتکاران کو اپنے ضروری نجی استعمال کے واسطے مفت گھاس کاٹنے کی اور اپنے موشی مفت چرانے کی اجازت ہے ۔ (2) Owners of animals employed in the export of forest produce are permitted to cut fodder grass free of charge for feeding those animals. (२) पैदावार जंगल की निकासी के लिये जो जानवर इस्तेमाल किये जायेंगे उनके लिये चारा घास बिला महसूल काटने की इजाजत है। (۲) پیداوار جنگل کی نکاسی کے لئے جو جانور استعمال کئے جائینگے اُن کے لئے چارہ گھاس بلا محصول کاٹنے کی اجازت ہے ۔
08 ०८ ١٠٨	Ditto ऐ० ایضاً	Chandarbani forest (Karwapani and Laldhang blocks). चन्दरबनी जंगल (कडुवा पानी और लालढांग ब्लौक) چندربنی جنگل (کڑواپانی اور لالڈھانگ بلاک)					
09 ०९ ١٠٩	Lachiwala लच्छीवाला لچھیوالا	Bullawala forest (Balindawala, Amsot and Jhabrawala blocks). बुल्लावाला जंगल (बलिन्दावाला आमसोत व झबरावाला ब्लौक) بلاوالا جنگل (بلندا والا امسوت و جھبراوالا بلاک)					
10 १० ١١٠	Motichoor मोतीचूर موتی چور	Bahera, Koelpura (excluding c. 4b, c. 5b and c. 9), Jamankhata, Banbaha and Chandi blocks. बहेड़ा, कोयलपुरा (अलावा कम्पार्ट ४ ब, ५ ब और ९), जामनखाता, बनबहा और चांडी ब्लौक بہیڑا - کوئل پورہ (علاوہ کمپارٹ ۴ب - ۵ب اور ۹) جامن کھاتہ بنبہا اور چانڈی بلاک					
11 ११ ١١١	Ditto ऐ० ایضاً	Motichoor (excluding c. 1b, c. 5a, and c. 7b), Danda, Johra and Suswa blocks. मोतीचूर (अलावा कम्पार्ट १ ब, ५ अ और ७ ब) डांडा, जोहड़ा और सुसवा-(सा) ब्लौक। موتی چور (علاوہ کمپارٹ ۱ب - ۵الف اور ۷ب) ڈانڈا جوھڑا اور سسوا بلاک					

HIDES, HORNS, AND BONES, EXCEPT THOSE OF WILD ANIMALS, LUMP SUM SALE

चरम मुरदार, सींग और हड्डियां सिवाय जंगली जानवरों के गोल ठेके पर बेचने के लिये

چرم مردار - سینگ اور هڈیان سواے جنگلی جانورون کے گول ٹھیکہ پر بیچنے کے لئے

Lot No. लाट नं० لاٹ نمبر	Range रेंज رینج			Locality and boundary जगह और हद جگهه اور حد			Price realized	Security money	Period for work and export मियाद काम और निकासी میعاد کام اور نکاسی	Name of purchaser	Remarks कैफ़ियत کیفیت
112 ११२ ١١٢	Timli	टिमली	ٹملی	Whole Range	कुल रेंज	کل رینج			September 30, 1936. ३० सितम्बर १९३६ ई० ٣٠ ستمبر سنہ ١٩٣٦ع		Hides, horns, and bones of the dead cattle belonging to the *taungya* cultivators are not included in the sale. टोंगिया के काश्तकारान के मवेशी जो मरेंगे उनका चमड़ा, सींग, और हड्डी बिक्री में शामिल नहीं है । ٹونگیا کے کاشتکاران کے مویشی جو مرینگے اُن کا چمڑا - سینگ اور هڈی فروخت مین شامل نہین هین ۰
113 ११३ ١١٣	Malhan	मलहान	ملہان	Ditto	ऐज़न	ایضاً					
114 ११४ ١١٤	Lachiwala	लच्छीवाला	لچھیوالا	Ditto	ऐज़न	ایضاً					
115 ११५ ١١٥	Thano	थानो	تھانو	Ditto	ऐज़न	ایضاً					
116 ११६ ١١٦	Barkot	बड़कोट	بڑکوٹ	Ditto	ऐज़न	ایضاً					
117 ११७ ١١٧	Motichoor	मोतीचूर	موتیچور	Ditto	ऐज़न	ایضاً					

HONEY AND WAX LUMP SUM SALE

शहद और मोम गोल ठेके पर बेचने के लिये

شہد اور موم گول ٹھیکہ پر بیچنے کے لئے

Lot No. लाट नं० لاٹ نمبر	Range रेंज رینج	Locality and boundary जगह और हद جگہہ اور حد	Price realized	Security money	Period for work and export मियाद काम और निकासी میعاد کام اور نکاسی	Name of purchaser	Remarks कैफ़ियत کیفیت
118 ११८ ١١٨	Timli टिमली تملی	Whole Range कुल रेंज کل رینج			May 31, 1936. ३१ मई १९३६ ई० ٣١ مئی سنہ ١٩٣٦ء		
119 ११९ ١١٩	Malhan मलहान ملہان	Ditto ऐज़न ایضاً					
120 १२० ١٢٠	Lachiwala लच्छीवाला لچھی والا	Ditto ऐज़न ایضاً					
121 १२१ ١٢١	Thano थानो تھانو	Ditto ऐज़न ایضاً					
122 १२२ ١٢٢	Barkot बबकोट بڑکوٹ	Ditto ऐज़न ایضاً					
123 १२३ ١٢٣	Motichoor मोतीचूर موتی چور	Johra, Suswa, Chandi and Banbaha blocks. जोहड़ा, सुस्वा, चांडी और बनवहा ब्लौक جوہڑا - سسوا - چانڈی اور بن‌بہا بلاک					

DEHRA DUN:
June 15, 1935.

Divisional Forest Officer, Dehra Dun Division.

VII

SAMPLE SPECIFICATIONS OF SLEEPERS USED IN INDIA

MADRAS FOREST DEPARTMENT

1. A sleeper must be cut from one of the approved species of timber. *Tectona grandis, Hopea parviflora, Mesua ferrea,* and *Xylia xylocarpa* are the approved timbers for Madras.
2. It should be cut from timber which is sound and free from rot.
3. It should not contain more than 40 per cent of sapwood.
4. The rail bearing-surface and the section to be directly under the rails must be of heartwood. The heartwood at this point must be of dimensions at least as much as those laid down in condition 7 *infra*
5. It must be straight in plan as well as in elevation.
6. It must not be more than 3 inches too short or 3 inches too long over the specified or standard sizes.
7. In the case of a Broad-Gauge sleeper, it must not be more than one inch too narrow or half an inch too thin. In the case of a Metre-Gauge sleeper, it must not be more than $\frac{3}{4}$ inch too narrow or $\frac{1}{2}$ inch too thin.
8. It must not be badly split through at both ends.
9. It must not be nearly split through at both ends and have the split along its length on one end.
10. Unless advised to the contrary it must be properly bound at both ends with hoop iron. This applies to all the sleepers for the South Indian Railway: sleepers intended for the M. and S.M. Railway need only be bound if the ends are slightly split or show a tendency to split.
11. Both ends must be properly squared and clean.
12. The timber must not be cross-grained, badly knotted or bee-holed.
13. It must not contain heart shakes.
14. It must ring sound on being hit with a hammer.
15. It must not contain cumulative defects, which will reduce its strength more than 10 per cent below that of a sound sleeper.

SLEEPER POOL COMMITTEE SPECIFICATIONS

I. Terai Group

Metre-gauge sal sleepers

The sleepers to be cut from well-matured and clean grown sal wood. Each sleeper to measure not less than 6′×8″×4½″. Sleepers must not be sawn from a log which has not a cross-section sufficiently large to enable at least two sleepers to be cut therefrom.

The sleepers to be of sound timber, free from flaws, and shakes, and knots.

Sleepers must be entirely free from sapwood for a distance of at least six inches on each side of the centre of the rail seat; a small portion of sapwood elsewhere on two corners only, not extending into sleepers to a depth of more than one inch, will be accepted.

II. Northern Group

First class sleepers of deodar, chir, kail, fir, and spruce

Sleepers must be sound, absolutely free from fungoid growth, rotten wood, insect attack, serious cracks, or serious end shakes, and must be well seasoned.

The following details are to be observed by suppliers and are points on which the classification of first class sleepers must be based:—

Serial No.		Deodar	Chir, *kail*, fir, and spruce
1	Maximum period allowed in a depot of the plains before presentation	....	Six months
2	Minimum period required in a depot of the plains before passing	One month ..	One month
3(*a*)	Dimensions of broad-gauge sleepers at time of presentation	9′×10″×5″ ..	9′×10″×5″
3(*b*)	Dimensions of metre-gauge sleepers at time of presentation	6′×8″×4½″ ..	6′×8″×4½″
4	Position of heart centre	Heart centre included in both ends of a sleeper not permitted. Where a sleeper does not contain the heart centre in one end or where the heart centre has been sawn longitudinally through the heart	The same as for deodar

Serial No.		Deodar	Chir, *kail*, fir, and spruce
		centre, the heart centre may be permitted to fall within the cross-section of the sleeper at the other end provided it is not further than 1½″ from the nearest edge of the sleeper. Where the heart centre is not included in the sleeper the annual rings must not be perpendicular to the broad face	
5	Maximum spring allowed	2″ for broad-gauge sleeper 1½″ for metre-gauge sleeper	2″ for broad-gauge sleeper 1½″ for metre-gauge sleeper
6	Maximum cup allowed	⅛″ for broad-gauge sleeper ¼″ for metre-gauge sleeper	½″ for broad-gauge sleeper ¼″ for metre-gauge sleeper
7	Winding: only so much allowed that maximum adzing required to seat the bearing plates does not exceed in depth	¼″	¼″
8	Largest tight knot allowed within 6 inches from centre of rail seat and not more than one	1″ in diameter ..	1″ in diameter
9	Largest tight knot allowed away from rail seat (a knot or group of knots must not materially affect the strength)	3″ in diameter ..	3″ in diameter
10	Sapwood ..	Not more than 10 per cent at any section and one broad face entirely free	No limit for sapwood [1]
11	Wane	1″ wane is allowed, provided that it does not cause an excess of 10 per cent of sapwood	1″ wane is allowed
12	Twisted fibre ..	....	For chir only Percentage of fibres that must run through the whole of the sleepers:—

[1] The reason for this is that all sleepers of the species in this column are treated.—AUTHOR.

Serial No.		Deodar	Chir, *kail*, fir, and spruce
			On either broad face 20 per cent On either depth face 20 per cent To be within the above limit on the width face, the fibre starting from the top corner at one end of the sleeper should finish at above 2" from the bottom corner at the other end To be within the above limit on the depth face, the fibre starting from the top corner at one end of the sleeper should finish at above 1" from the bottom corner at the other end

III. Eastern Group

Sal sleepers [1]

1. The work required of the contractor under this specification consists of the supply and delivery of sal sleepers loaded into railway wagons and booked as directed by the Sleeper Control Officer of the Eastern Group from the stations named on the Bengal Nagpur, East Indian, Eastern Bengal, and Assam-Bengal Railway system. The sleepers shall be supplied in strict accordance with the following sizes and to the entire satisfaction of the Sleeper Control Officer, Eastern Group, whose decision whether a sleeper is to be accepted or rejected will be final and binding on both parties.

Broad-Gauge (B.G.) sleepers shall measure not less than 9 ft. long, 10 in. wide, and 5 in. thick.

Metre-Gauge (M.G.) sleepers shall measure not less than 6 ft. long, 8 in. wide, and 4½ in. thick.

Narrow-Gauge (N.G.) sleepers shall measure not less than 5 ft. long, 7 in. wide, and 4½ in. thick.

2. The sleepers shall be sawn from sound sal logs. They shall be straight and out of winding and with faces square to one another. The wood in the sleeper shall be free from sapwood, heart shakes, serious cracks, split ends, and

[1] New and more detailed specifications are now in use by the Eastern Group.

large knots, and free from anything near the rail seat which might interfere with the driving or screwing of spikes. Sleepers with the heart boxed will not be accepted.

3. All sleepers presented for inspection must bear the contractor's private mark. A true facsimile of the mark proposed to be adopted with such stamped samples as may be required must be furnished to the Sleeper Control Officer, Eastern Group, and his approval in writing obtained for it, such approval to be obtained before sleepers are tendered for inspection.

4. The interpretation of the specification as to whether a sleeper is to be accepted by the Group or rejected is at the sole discretion of the Sleeper Control Officer whose decision is final and binding on both parties.

IV. Burma

1. The work required under this specification consists of the supply and delivery by the contractor of Burma sleepers loaded into ships and booked with freight and insurance to destination as directed by the Sleeper Control Officer, Eastern Group. The sleepers shall be supplied in strict accordance with the following sizes and to the entire satisfaction of the Sleeper Control Officer, Eastern Group.

Broad-Gauge (B.G.) sleepers shall measure not less than 9 ft. long, 10 in. wide, and 5 in. thick.

Metre-Gauge (M.G.) sleepers shall measure not less than 6 ft. long, 8 in. wide, and $4\frac{1}{2}$ in. thick.

2. The sleepers shall be sawn from sound well-seasoned logs and shall not be offered for passing until at least one month after they have been sawn, the Sleeper Passing Officer being at liberty to refuse to inspect any sleeper which he may be led to believe has not been sawn for one month. The sleepers shall be straight and out of winding and with faces square to one another. The wood in the sleepers shall be free from sapwood, heart shakes, serious cracks, split ends, and large knots and free from anything near the rail seat which might interfere with the driving or screwing of spikes. Sleepers with excessive wane which lessens the strength of the sleeper, or wane near the rail seats which offers an appreciably diminished rail seat, will not be accepted. Sleepers with the heart boxed will not be accepted.

3. All sleepers presented for inspection must bear the contractor's private mark. A true facsimile of the mark proposed to be adopted with such stamped samples as may be required must be furnished to the Sleeper Control Officer and the Sleeper Passing Officer and the Sleeper Control Officer's approval in writing obtained. All sleepers offered against this contract should be branded by the

contractor with a brand recognized as indicating the timber the sleeper consists of. If it is found that a sleeper is branded thus by a contractor and does not bear a brand true to species of wood, the Group is at liberty to consider this a breach of contract and cancel the contract.

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